RECLAMATION

Managing Water in the West

PROGRAMMATIC BIOLOGICAL ASSESSMENT: GUNNISON RIVER BASIN, COLORADO: OPERATIONS OF THE WAYNE N. ASPINALL UNIT; OPERATIONS AND DEPLETIONS OF EXISTING RECLAMATION PROJECTS; AND OPERATIONS AND DEPLETIONS OF NON-FEDERAL WATER DEVELOPMENT

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United States Department of Interior
Bureau of Reclamation
Upper Colorado Region
Western Colorado Area Office

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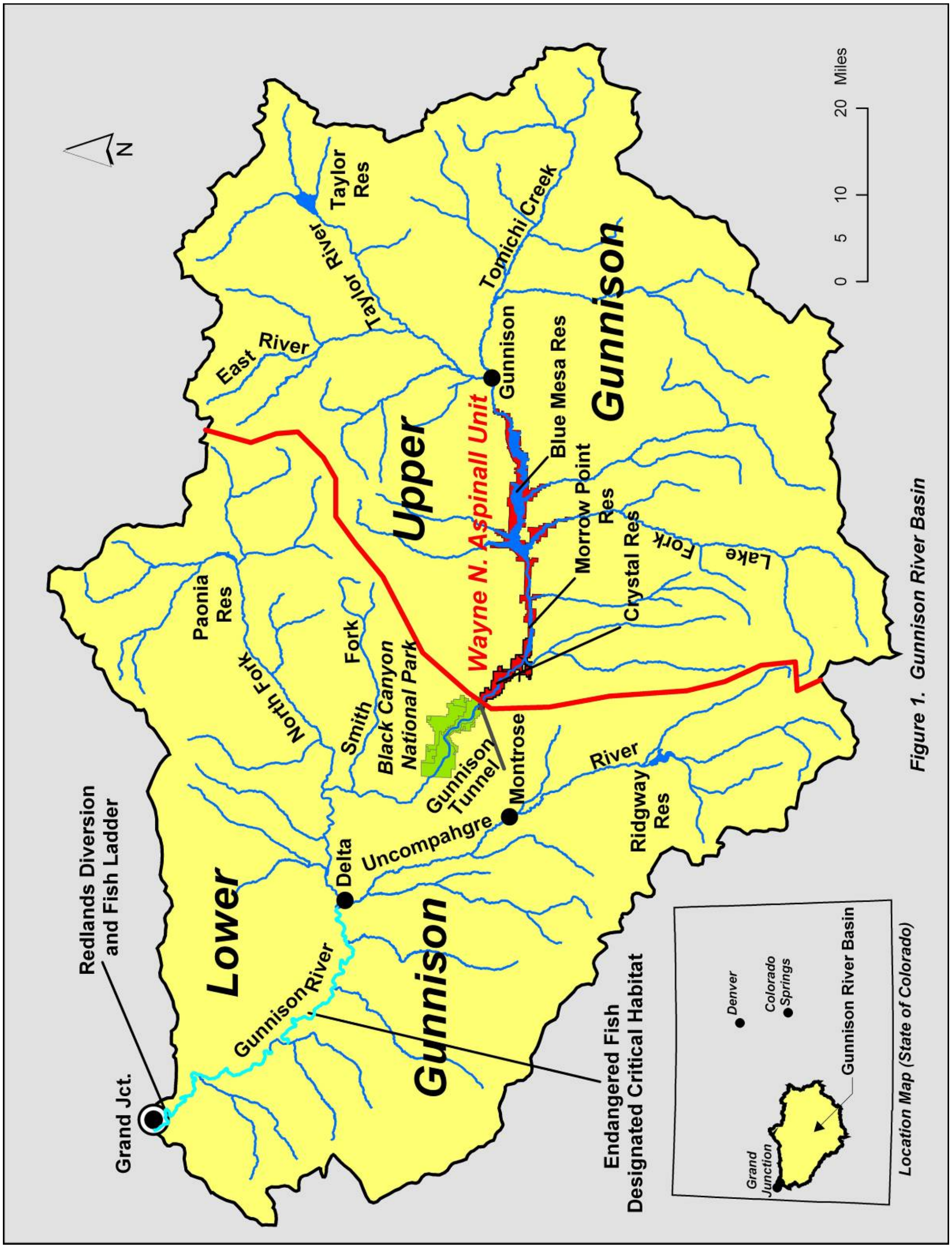
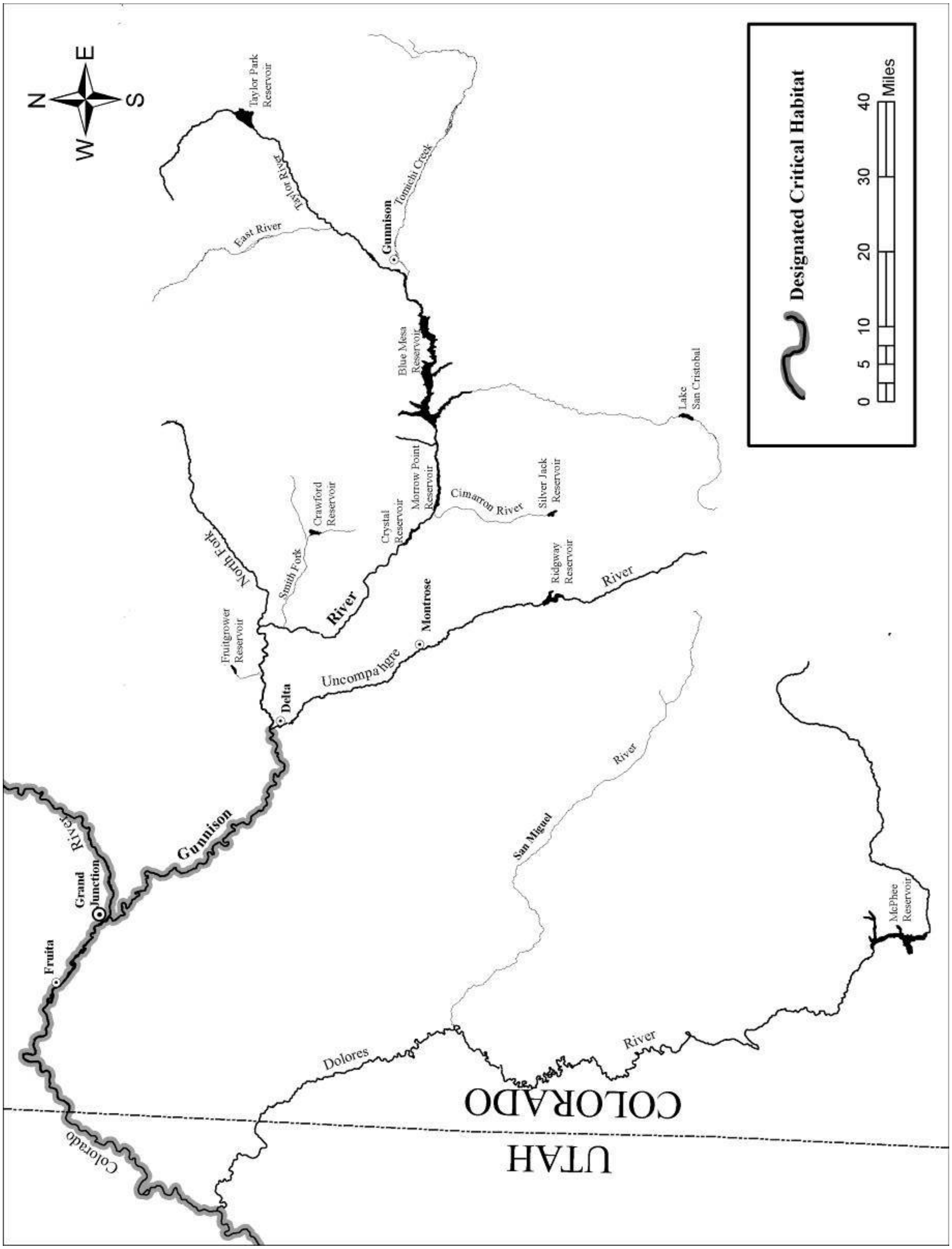


Figure 1. Gunnison River Basin



N
E
S
W
Taylor Park Reservoir
Taylor River
Tomichi Creek
Gunnison
East River
Blue Mesa Reservoir
Morrow Point Reservoir
Crystal Reservoir
Lake San Cristobal
Cimarron River
Silver Jack Reservoir
Crawford Reservoir
Smith Fork
North Fork
River
Ridgway Reservoir
River
Montrose
Fruitgrower Reservoir
Uncompahgre
Delta
Gunnison
River
Grand Junction
Fruita
San Miguel
River
McPhee Reservoir
Dolores
River
COLORADO
UTAH
Colorado
Designated Critical Habitat
0 5 10 20 30 40
Miles

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1.0 INTRODUCTION

1.1 General

The Bureau of Reclamation (Reclamation), in cooperation with interested non-federal parties, is submitting this programmatic biological assessment (PBA) to the Fish and Wildlife Service (Service) in compliance with Section 7(a)(2) of the Endangered Species Act (ESA), 16 U.S. Code 1536(a)(2). This PBA addresses the potential effects of Reclamation's discretionary actions related to water management operations throughout the Gunnison Basin, and Dolores Project operations in the Dolores River/Colorado River basins in west central Colorado and eastern Utah.

The purpose of this PBA is to evaluate the impacts of Reclamation's proposed action, which includes reoperation of the Wayne N. Aspinall Unit (Aspinall Unit), on threatened, endangered, and candidate species and on critical habitat. Preparation of the PBA has been coordinated with the state and private agencies/organizations in the action area. Foreseeable future changes to the environment that result from continuation of state and private water related actions are included in the PBA effects analysis.

The Service has cited 9 endangered, 4 threatened, and 2 candidate species potentially affected by the proposed action based on their presence in the Gunnison or portions of the Colorado River Basin (Fish and Wildlife Service 2008):

Clay-loving wild buckwheat	*Eriogonum pelinophilum*	endangered
Uinta Basin hookless cactus	*Sclerocactus glaucus*	threatened
Jones' cycladenia	*Cycladenia humilis var. jonesii*	threatened
Yellow-billed cuckoo	*Coccyzus americanus*	candidate
Mexican spotted owl	*Strix occidentalis lucida*	threatened
Southwestern willow flycatcher	*Empidonax traillii extimus*	endangered
California condor	*Gymnogyps californianus*	endangered
Colorado pikeminnow	*Ptychocheilus lucius*	endangered
Razorback sucker	*Xyrauchen texanus*	endangered
Humpback chub	*Gila lacypha*	endangered
Bonytail	*Gila elegans*	endangered
Black-footed ferret	*Mustela nigripes*	endangered
Canada lynx	*Lynx Canadensis*	threatened
Gunnison's prairie dog	*Cynomys gunnisoni*	candidate
Uncompahgre fritillary butterfly	*Boloria acrocnema*	endangered

The timeframe addressed in the assessment is considered to be 25 years from completion of the biological opinion. The action area for this assessment is the Gunnison River Basin and the Upper Colorado River downstream from the Gunnison confluence to the

Dolores River confluence and downstream to Lake Powell. The Aspinall Unit itself is located in Gunnison and Montrose Counties, Colorado, along a 40-mile reach of the Gunnison River as shown on the frontispiece maps. Downstream from the Aspinall Unit, the Gunnison River also flows through Delta and Mesa Counties. The Aspinall Unit consists of a series of three dams and reservoirs: Blue Mesa, Morrow Point, and Crystal. The Aspinall Unit was authorized by the Colorado River Storage Project Act of 1956 (CRSPA) along with Glen Canyon, Flaming Gorge, and the Navajo Unit. All are operated by the Reclamation. The authorization calls for meeting a variety of purposes listed in Section 2.7.

1.2 Summary of the Proposed Action

1.2.1 Federal Action

"Action" is defined as all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies. The Service's regulations at 50 CFR 402.03 provide that Section 7 applies to all actions in which there is discretionary Federal involvement or control.

The proposed Federal action analyzed in this PBA includes those discretionary actions proposed by Reclamation regarding water operations and management in the Gunnison Basin and in the portion of the Colorado River affected by the Dolores Project and Aspinall Unit. The elements of the Federal action are:

- Reclamation's modification of the operation of the Aspinall Unit to avoid jeopardy to downstream endangered fish in the Gunnison and Colorado rivers. The new operation is designed to increase downstream spring peak flows while maintaining moderate base flows. A detailed description is found in Section 2.1.2.
- The continuation of all of Reclamation Project operations in the Gunnison River Basin. Reclamation projects are: Smith Fork, Paonia, Fruitgrowers, Bostwick Park, and Uncompahgre (Attachment 1).
- The continued operation of the Dolores Project (Attachment 1) in the Dolores Basin, included based on a prior biological opinion Reasonable and Prudent Alternative, and reinitiation of consultation on it to address new listed species and depletions.
- The continued operation of the Dallas Creek Project (Attachment 1) included based on a prior biological opinion Reasonable and Prudent Alternative, and reinitiation of consultation on it to address new listed species and depletions.
- Actions undertaken by the Service, Reclamation, the National Park Service, and Western Area Power Administration in the funding and carrying out of recovery actions for the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin (Recovery Program) that affect the Gunnison Basin. See Section 2.8.

- The continued operation and use of water rights of Federal agencies such as the Bureau of Land Management, Forest Service, and National Park Service. These are generally small stock watering facilities or wells and springs.

1.2.2 Non-Federal Action

In addition to Reclamation actions, there are state organizations and private entities in the action area included in this consultation.

- The continuation of the operations and depletions of all non-Federal projects and water uses in the Gunnison Basin. Average annual depletions from these uses are estimated at approximately 250,000-275,000 acre-feet (af).
- The future depletion 3,500 af of unspecified depletions in the Gunnison Basin is also included in the action as well as 30,800 af of Aspinall Unit water rights subordinated to upstream uses.

1.3 General Description of Action Area

The Gunnison River originates where the East and Taylor Rivers join at Almont, Colorado, in Gunnison County, Colorado (Frontispiece). From that point, the river flows 25 miles to Blue Mesa Reservoir and on through Morrow Point and Crystal Reservoirs. From Crystal Reservoir, it flows approximately two miles to the Gunnison Tunnel. From the Gunnison Tunnel, the river flows for 29 miles to the confluence with the North Fork of the Gunnison (North Fork). It then travels 75 miles to its confluence with the Colorado River at Grand Junction, Colorado. The lower river has been divided into river miles (RM) for research purposes. Key river miles are listed below:

- RM 0 Colorado River confluence
- RM 3 Redlands Diversion
- RM 12 Craig Bottomland pond
- RM 14 Whitewater gage
- RM 18 Kannah Creek confluence
- RM 23 Deer Run
- RM 29 Deer Creek confluence (Bridgeport)
- RM 30 Dominquez Creek
- RM 35 Peeples Orchard
- RM 38 Wells Gulch
- RM 42 Escalante Creek
- RM 50 Roubideau Creek
- RM 53 Escalante State Wildlife Area backwaters
- RM 56 Uncompahgre River confluence
- RM 60 Hartland Diversion
- RM 65 Austin
- RM 75 North Fork confluence
- RM 104 Gunnison Tunnel
- RM 106 Crystal Dam

The area of the watershed upstream from the Aspinall Unit is approximately 4,000 square miles. At the U.S. Geological Survey gage downstream from the Gunnison Tunnel and Crystal Dam, historical average annual flows have been 1,320 cubic feet per second (cfs) and mean daily flow extremes pre-Aspinall Unit ranged from a few days of no flows to 19,000 cfs. Another important measurement point on the river is the U.S.G.S.

Whitewater gage (Gunnison River near Grand Junction), 14 miles upstream from the Colorado River confluence. At this point the drainage area is roughly 8,000 square miles, average monthly flows are approximately 2,600 cfs, and pre-Aspinall Unit extremes ranged from 106 cfs to over 35,000 cfs.

The upper portion of the Gunnison River Basin is characterized by mountainous landscape with perennial mountain streams that peak during spring snow melt. The basin area is moderately wet to semi-arid; the major part of this area being greater than 6,000 feet in elevation. Major tributaries include the East and Taylor Rivers, Tomichi Creek, the Lake Fork, and Cimarron Creek. Vegetation ranges from mixed conifer and aspen in the mountain areas to sagebrush communities in the valleys. Predominant riparian vegetation consists of narrowleaf cottonwood, box elder, willows, spruce, and other conifers. The town of Gunnison is the major community in the upper basin.

The lower (western) portion of the Gunnison River Basin is characterized by desert landscape with two major tributaries-the North Fork and the Uncompahgre River. There are also small perennial tributaries and intermittent washes that carry significant sediment loads during periodic thunderstorms. The area is semiarid to arid; the major part of this area is less than 6,000 feet in elevation and receives less than 8 inches of precipitation annually. Vegetation ranges from pinon-juniper on mesa tops to desert shrubs and grasses near the lower Gunnison and Colorado rivers. The river supports riparian vegetation such as cottonwood, willow, and non-native salt cedar and Russian olive. The Black Canyon of the Gunnison National Park and the Gunnison Gorge National Conservation Area are downstream from Crystal Dam. The cities of Delta and Grand Junction are located along the lower Gunnison River.

The Colorado River downstream from the Gunnison River confluence flows through the Grand Valley and then enters Utah and eventually Lake Powell. Lands along the Colorado River are semi-arid with numerous canyon reaches.

There are no significant water imports to or exports from the Gunnison Basin. Approximately 1,600 af are imported and 3,500 af are exported. This excludes consideration of the two diversions near the mouth of the river, the Redlands Diversion (approximately 510,000 af) and the Grand Junction water system (approximately 7,000 af).

There are approximately 264,000 irrigated acres in the basin and irrigation represents the major water use (Colorado Department of Natural Resources 2006). Major private and federal storage reservoirs in the basin are tabulated in Table 1.

Average annual depletions above the Whitewater gage are approximately 450,000-500,000 af. Approximately 45% of the depletions are related to Federal projects and 55% to private projects.

Table 1. Major water storage reservoirs, Gunnison Basin.

Reservoir	Total storage capacity (acre-feet)
Blue Mesa Reservoir	940,700
Morrow Point Reservoir	117,190
Taylor Park Reservoir	106,700
Ridgway Reservoir	94,176
Crystal Reservoir	25,240
Paonia Reservoir	20,950 (15,977 present capacity)
Crawford Reservoir	14,395
Silver Jack Reservoir	13,520
Gould Reservoir	9,000
Overland Reservoir	5,828
Fruitgrowers Reservoir	4,540 (3,576 present capacity)

Annual evaporation depletions at the Aspinall Unit averaged 8,100 acre-feet in the 2001-2005 period and 8,700 af in the 1975-1995 period. Depletions from water sales from the Aspinall Unit are less than 1,000 af annually.

2.0 DESCRIPTION OF PROPOSED ACTION

2.1 Aspinall Unit Operations

This section describes the process that Reclamation will use to implement the proposed modification of Aspinall Unit operations while maintaining other authorized purposes and assuring safe operations. The modification of the operations of the Aspinall Unit portion of the proposed action will be implemented by Reclamation following signature of a Record of Decision prepared under the National Environmental Policy Act.

RiverWare was the simulation software selected by Reclamation for use in the development of a hydrology model to be used to evaluate and compare alternatives. The Gunnison River model simulates historic hydrology from 1975 to 2005. This period of record was selected as the most complete historical dataset at the time that model analysis began. The initial conditions of the Gunnison River model were selected to be the state of the Aspinall Unit and Gunnison River system at the start of January of 1975. The Gunnison River model runs for the 31 year period between 1975 and 2005. The model runs a single trace of 31 years during this time period. The model separates annual reservoir operations into 3 time periods: January-March, April-July, and August-December. Basic daily input data to the model are: historic Blue Mesa inflows, both actual and unregulated; historic side inflows to Morrow Point and Crystal; Gunnison Tunnel diversions; and various downstream gains computed from actual gage data. Other data provided as input to the model include forecasted inflow and Gunnison Tunnel demands for each forecast period.

The model will not be used for actual operations. Operations of the Aspinall Unit will be based upon forecasted inflow volume to Blue Mesa Reservoir as well as other factors such as storage levels, physical capabilities of the facilities, and flood control to determine the magnitude, duration, and timing of releases. The spring inflow is highly variable and dependent on the previous winter's snowpack. For example, between 1975 and 2005 the April-July Blue Mesa inflow ranged between 166,700 af in 1977 and 1,434,000 af in 1984. Because of this, the operating plan will vary from year to year based on the forecasted inflow to Blue Mesa Reservoir.

In terms of downstream endangered fish, the new operation plan has four basic goals:

- Attempting to meet spring peak targets as outlined in the Flow Recommendations;
- Attempting to meet minimum duration targets for half bankfull discharge and bankfull discharges pursuant to the Flow Recommendations;
- Attempting to meet targets for base flows as outlined in the Flow Recommendations; and
- Attempting to meet fish ladder, fish screen, and migration flows at and below the Redlands Water and Power Diversion Dam (Redlands Diversion).

2.1.1 Flow Recommendations

Flow Recommendations (McAda 2003) can be found at
http://www.usbr.gov/uc/wcao/rm/aspeis/pdfs/GunnCoFlowRec.pdf

Flow Recommendations for the Gunnison and mainstem Colorado rivers were published by the Recovery Program (McAda 2003) and recommend flows designed to create and maintain habitat conditions that the four endangered fish species require for all aspects of their life history. Flow Recommendations were developed during conditions including the existence and operation of the Aspinall Unit. In general, the recommendations concentrate on a more natural hydrograph with high spring peak flows and moderate base flows; the flow recommendations vary from year to year based on snowpack and forecasted spring runoff. The flow "targets" in the recommendations are measured at the U.S.G.S. gaging station at Whitewater on the Lower Gunnison River. In addition, recommendations for the Colorado River are targeted at the U.S.G.S. Colorado-Utah stateline gaging station. Flow Recommendations are summarized in Attachment 2.

While habitat needs of the endangered fish vary between species, spring peak flows benefit all the species by accomplishing several physical goals in addition to providing cues for migration and spawning:

- Maintain complex in-channel habitats
- Provide access to floodplains
- Minimize vegetation encroachment, channel narrowing, and vertical accretion, thus protecting side-channel habitats
- Form low-velocity habitats for staging, feeding, and resting during runoff
- Inundate and maintain connections to floodplains and off-channel habitat to provide warmer water food-rich conditions for larval and adult fish
- Provide clean spawning substrates and adequate interstitial spaces for periphyton and aquatic invertebrates

Overall, the priority in the Flow Recommendations is peak flows in the spring. Also included are relatively high base flows in wet years and relatively lower base flows in drier years. Flow Recommendation targets are based on meeting half bankfull and bankfull discharges to reach or exceed thresholds for sediment movement with higher instantaneous peaks in some years.

Pitlick et al. (1999) summarized the importance of spring flows in moving sediment:

> The single most important thing that can be done to maintain habitats used by the endangered fishes is to assure that the sediment supplied to the critical reaches continues to be carried downstream. Sediment that is not carried through will accumulate preferentially in low velocity areas, resulting in further channel simplification and narrowing.

Pitlick et al. (1999) also provided specific flow targets based on Gunnison River field studies:

> Flows equal to or greater than one-half the bankfull discharge are needed to mobilize gravel and cobble particles on a widespread basis and to prevent fine sediment from accumulating in the bed…Flows greater than one-half the bankfull discharge thus provide several important geomorphic functions, assuming they occur with sufficient regularity. Flows equal to bankfull discharge are also important because they fully mobilize the bed and thereby maintain the existing bankfull hydraulic geometry.

As discussed in Section 3.2, the median value for half bankfull flows is 8,070 cfs and the half bankfull flow range is 4,660 to 12,700 cfs as determined from 54 different cross sections along the Gunnison River in critical habitat. The median value for bankfull flows is 14,350 cfs with a range of 7,352 to 28,000 cfs. Corresponding median values for the Colorado River at the Colorado-Utah stateline are 18,500 cfs and 35,000 cfs.

Fish and Wildlife Service (2004) referred to several studies in the Upper Colorado Basin that indicated a relationship of strong year classes of pikeminnow with hydrologic conditions that included a spring and summer of moderately high flows following a year of exceptionally high flows.

Bottomland or floodplain habitats provide important habitat to several life stages of endangered fish. Irving and Burdick (1995) studied bottomlands on the Gunnison River. In 1993, 48 bottomland sites were identified on the Gunnison River with a total potential area of 3,227 acres. Of this total, approximately 828 acres were inundated at spring flows (of approximately 14,000 cfs) and 161 acres at lower fall flows (approximately 2,400 cfs). Limited inundation of floodplains began around 5,000 - 6,000 cfs; however, significant acreage inundation did not occur until flows reached 10,000-15,000 cfs. Bottomlands included terraces, depressions, gravel pits, oxbows, side channels, and canyon mouths.

The majority of the floodplain habitat within critical habitat in the Gunnison River is located between Delta and the confluence with Roubideau Creek-- Johnson Boys' slough, Escalante State Wildlife Area (SWA), Confluence Park, Morgan, and Fedler (Valdez and Nelson 2006). The greatest potential for flooded habitat occurs at the Escalante SWA (RM 50-52) where the greatest relative gain in flooded habitat occurs as flows increase to 10,000 cfs. McAda and Fenton (1998) evaluated available habitat in Escalante SWA in relation to flow and determined that little relative gain occurs between 981 and 5,560 cfs, but substantial increases occur between 5,560 and 13,300 cfs and diminish again at higher levels. The Johnson Boy's slough (RM 52-54) is another important site. Further downstream, the river enters a valley in the Whitewater area where railroad construction and other developments have restrained the river in the main channel since the late 19th century. A few sites are located close to the Colorado River confluence-for example the Craig site that has been acquired and improved by the Recovery Program. Water begins to enter the Craig site as flows reach 4,500 to 5,000 cfs.

Among Gunnison River floodplain habitats, the Recovery Program prioritized the Johnson Boy's slough and Escalante SWA as #2 and #8 among 26 potential sites in the entire Upper Colorado River basin (Valdez and Nelson 2006). Prioritizations were based on location, size, connectivity and land ownership. In the Colorado River below the Gunnison River confluence, nineteen sites were identified. Of these, Walter Walker SWA was ranked #1 in the entire Upper Colorado River basin, and the Panorama site was ranked #6 overall.

To incorporate natural variation in the river system, flow recommendations were developed for six hydrological categories based on April-July runoff volumes. An indication of the variability of water availability in the Gunnison River is the range of April-July runoff volume at Whitewater – 281,000 af in 1977 and 3,147,000 af in 1984. The six hydrological categories are:

- Wet years: April-July runoff volume has been equaled or exceeded 10% of the time during the study period.
- Moderately wet years: April-July runoff volume has been equaled or exceeded 10-30% of the time during the study period.
- Average wet years: April-July runoff volume has been equaled or exceeded 30-50% of the time during the study period.
- Average dry years: April-July runoff volume has been equaled or exceeded 50-70% of the time during the study period.
- Moderately dry years: April-July runoff volume has been equaled or exceeded 70-90% of the time during the study period.
- Dry years: April-July runoff volume has been equaled or exceeded 90% of the time during the study period.

Water inflow to Blue Mesa Reservoir for the six categories was estimated by McAda (2003) based on 1937-1997 data:

- Wet years: inflow of 1,123,000 af or greater

- Moderately wet years: inflow between 871,000 af and 1,123,000 af
- Average wet years: inflow between 709,000 af and 871,000 af
- Average dry years: inflow between 561,000 af and 709,000 af
- Moderately dry years: inflow between 381,000 af and 561,000 af
- Dry years: inflow less than 381,000 af

The Flow Recommendations adopted Pitlick's analysis that to maintain habitat conditions in the Gunnison and Colorado rivers, half bankfull and bankfull flows should occur with a long-term average duration equal to what occurred during 1978-1997 and that to improve habitat, the threshold flows should occur with a long-term average equal to what occurred during 1993-1997. "Pitlick et al.'s (1999) recommendation to maintain habitat conditions would mean that over the long term flows should exceed 8,070 cfs for an average of 20 days per year and flows should exceed 14,350 cfs for an average of 4 days per year. Their recommendation to improve habitat conditions requires that, over the long term, flows should exceed 8,070 cfs for an average of 32 days per year and flows should exceed 14,350 cfs for an average of 7 days per year" (McAda, 2003). While target durations are based on geomorphology studies, durations of higher flows are also important for maintaining use of floodplain and backwater habitats.

Table 2 presents one of the possible scenarios by which flow recommendations for the Gunnison River could be derived from Pitlick's work (McAda 2003).

Table 2. Peak flow recommendations for the Gunnison River-number of days per years the flows should exceed half bankfull and bankfull.

Hydrologic Category	Expected Occurrence	Flow Target and Duration Days/Year Greater or equal To 8,070 cfs*	Days/Year Greater or equal to 14,350 cfs*	Instantaneous Peak Flows cfs
Wet	10%	60-100	15-25	15-23,000
Moderately Wet	20%	40-60	10-20	14,350-16,000
Average Wet	20%	20-25	2-3	=/> 14,350
Average Dry	20%	10-15	0-0	=/> 8,070
Moderately Dry	20%	0-10	0-0	=/> 2,600
Dry	10%	0-0	0-0	~ 900-4,000
Long Term Weighted Average		20-maintenance 32-improvement	4-maintenance 7-improvement	

*Lower value in each range is for maintenance, higher value in each range is for improvement

Peak flows in the Gunnison River are recommended to occur between May 15 and June 15 and should be managed, to the extent possible, by matching peak flows in the North Fork of the Gunnison with peak releases from the Aspinall Unit.

Peak flow recommendations were developed in a similar manner for the Colorado River measured at the Colorado-Utah stateline (see Attachment 2 and McAda 2003).

A minimum base flow for the Gunnison River (as measured at Whitewater gage) of at least 1,050 cfs is recommended in all but moderately dry and dry years in order to protect quiet water habitats for the fish and provide migration flows below the Redlands Fish Ladder. Included would be flows of 100 cfs to operate the fish ladder. It has been recommended that the ladder be operated from April 1 through September 15 (Burdick 2001). During dry and moderately dry years, flow recommendations provide for flows decreasing below 1,050 cfs after the Colorado pikeminnow migration period. During wetter periods, base flow recommendations are higher.

The Flow Recommendations recognize uncertainties (Section 6.7) in understanding the biology of the fishes and the response of the fish and their habitat to flow changes. For that reason, the recommendations call for using adaptive management to respond to new knowledge and using monitoring to evaluate the physical response of the habitat and biological response of the fish to the flow regimes.

In summary, the Flow Recommendations call for peak flows to periodically prepare cobble and gravel spawning areas, to connect backwaters, and to maintain channel diversity; and sufficient flows to cue and allow migration. Base flows that promote growth and survival of young fish during summer, autumn, and winter are also provided.

2.2.2 Planned Operations

The plan modifies operations where Reclamation has discretion to do so. There are elements of existing operations that are non-discretionary and are not changed. These non-discretionary operations are based on legal authorities, existing water rights, structural limitations, structural safety consideration, flood control rules, and existing water service contracts. Attachment 3 contains more information on discretionary and non-discretionary operations.

Pursuant to the proposed operating regime, Reclamation will attempt to meet the desired spring peak, minimum duration, and base flow targets at Whitewater and below the Redlands Diversion.

The new operation plan makes releases that attempt to meet a spring peak target at the Whitewater gage at the time the North Fork of Gunnison River is near its peak (generally May 15 to May 31). Peak targets at Whitewater are based on the May 1 or May 15 "April through July forecast" of Blue Mesa unregulated inflow. The forecast is provided by the National Weather Service through the Colorado Basin River Forecast Center starting in January and is updated twice per month until the end of July.

Attachments 8 and 9 and Section 6.0 of this report summarize modeled results of the proposed action.

Operations are described on a seasonal basis:

- **January-March:**

Water would be released based upon the most recent April-July inflow forecast and downstream water demands with the goal of achieving a March 31st Blue Mesa Reservoir content target (determined from the January, February, and March 1st forecasted April-July Blue Mesa inflow) and with a goal of higher releases during January for power purposes. The March 31st target is intended to optimize Aspinall Unit operations for storage, flood control, and hydropower production.

The proposed action sets a minimum downstream release for instream flow, generally 300 cfs, but can be higher based on the previous year's operations that consider factors such as the fall brown trout spawn or downstream senior water rights. Maximum releases are limited to the 2,150 cfs Crystal powerplant capacity in most years. Generally the above release patterns would meet downstream base flow needs for endangered fish; if not, releases will be adjusted accordingly. Crystal releases will reregulate peaking releases from Morrow Point throughout the year to produce stable downstream flows.

- **April-July :**

Reclamation will not bypass the powerplant at Crystal Dam from April 1 through May 10, thus making more water available for a spring peak and/or duration flows (however, in order to reduce flooding risk, Reclamation may bypass the powerplant during this time period if Blue Mesa's forecasted inflow indicates that the Year Type is in a "Wet" category). This has the effect of holding water for 40 days that may have been bypassed unnecessarily if the runoff was over-forecasted that year. In addition to making water available for peak releases it also may improve the chance of filling Blue Mesa, with a slight risk of increasing flood frequency at Delta.

Peak releases will generally be made after May 10th and before June 1st in an attempt to match the peak from the North Fork in order to maximize the potential of meeting the desired peak at Whitewater. However, this timeframe could be altered to May 1-June 15 if appropriate for endangered species and other resource concerns. Crystal releases, and releases from Morrow Point and Blue Mesa as needed, would begin to be ramped up approximately 5 days prior to the predicted North Fork peak. Releases may be reduced in an attempt to reduce flooding if the Gunnison River at Delta approaches 14,000 cfs.

The magnitude of the desired peak at Whitewater is determined based on the "Year Type" category, as defined in the Flow Recommendations, in conjunction with the most recent forecast information as shown in Figure 1 and Table 3. Releases will be made from the Aspinall Unit using the necessary combination of available powerplants, bypasses and spillways, while attempting to reach the spring peak target. Reclamation's ability to meet a desired peak is limited by the physical constraints/availability of the Aspinall Unit outlet features in some years. For example, Blue Mesa water elevation may not be high enough to use its spillway.

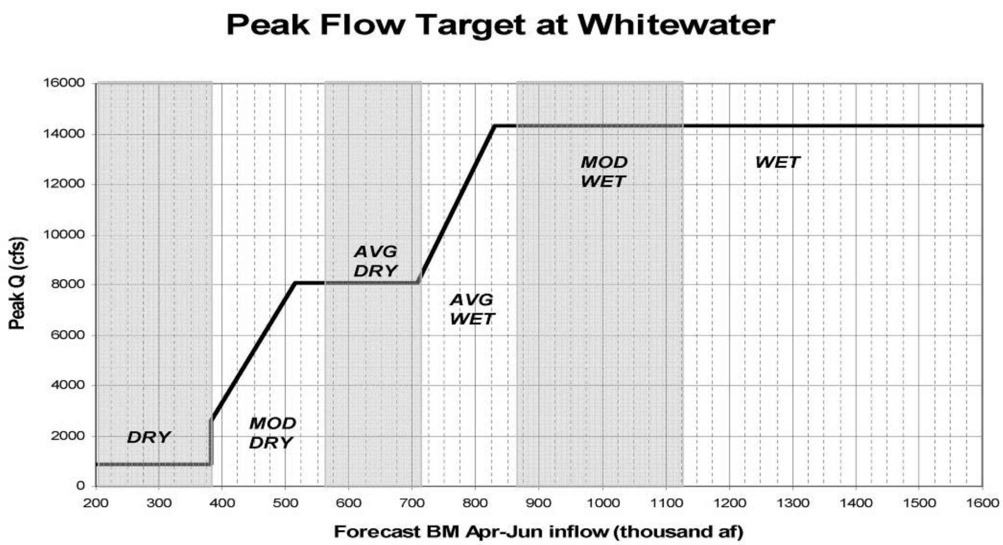


Figure 1. Determination of peak flow target

Table 3. Spring peak and duration targets for range of forecasted inflow.

Blue Mesa Forecasted Inflow	Peak Target @Whitewater	Duration of Half Bank (8,070 cfs)	Duration of Bankfull (14,350 cfs)
Acre-feet	cfs	Days	Days
< 381,000	900	0	0
381,000 to 516,000	2,600 to 8,070	0	0
516,001 to 709,000	8,070	10	0
709,001 to 831,000	8,070 to 14,350	20	2
831,001 to 1,123,000	14,350	40	10
> 1,123,001	14,350	60	15

After a peak flow release is made, high releases may continue in an attempt to maintain flows at half bankfull or bankfull levels. Releases for duration of higher flows in conjunction with the desired peak at Whitewater will be made if it is possible to reach 90 percent of the desired peak. The length of duration of flows is dependent on the "Year Type" category in the Flow Recommendations (see Tables 2 and 3). Minimum duration is targeted and may be exceeded at times.

- **August-December:**

Releases will be set utilizing the most recent forecast of August through December inflow and downstream senior water demands, with the goal of having Blue Mesa Reservoir at or below an elevation of 7,490 feet (580,000 af of live storage) by December 31st to minimize upstream icing. The minimum release criteria of 300 cfs for downstream resources will still apply, in addition to existing downstream senior water right demands (meaning that Blue Mesa will not store that portion of water needed to satisfy downstream senior water rights).

- **Ramping**

Ramping guidelines for release changes under the proposed action are as follows:

-Daily ramping rates on the ascending limb will be the maximum of 500 cfs or 25% of flow in Black Canyon on the previous day. Ramping can be accomplished with more than one change per day.
-Daily ramping rates guidelines for the descending limb will be the maximum of 400 cfs or 15% of flow in the Black Canyon on the previous day. Ramping can be accomplished with more than one change per day.
-Ramping up will begin 5 days prior to the estimated peak flow date on the North Fork Gunnison River.

- **Base flows**

Base flows are provided under the proposed action and can vary under different hydrologic conditions. Additional releases to maintain minimum base flows at Whitewater will be set each year based on discussions with the Service. In most years, a base flow of 1,050 cfs will be maintained at the Whitewater gage; however, this target will be reduced in dry or moderately dry years.

Table 4 summarizes base flow targets as outlined in the Flow Recommendations. As footnoted, additional releases will be made to provide 100 cfs to the Redlands Fish Ladder as needed in April through September and 40 cfs for the Redlands Fish Screen from March through November, using storage water if necessary. Base flows would normally provide adequate migration flows downstream from the Redlands Diversion.

Table 4. Base flow targets (cfs) at Whitewater Gage under the proposed action.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	1050	1050	1050	1050	1050	1500	1500	1500	1050	1050	1050	1050
Mod Wet	1050	1050	1050	1050	1050	1500	1500	1500	1050	1050	1050	1050
Avg Wet	1050	1050	1050	1050	1050	1500	1500	1050	1050	1050	1050	1050
Avg Dry	1050	1050	1050	1050	1050	1500	1500	1050	1050	1050	1050	1050
Mod Dry*	750	750	750/790	750/890	750/890	1050	1050	1050	750/890	750/790	750	750
Dry*	750	750	750/790	750/890	750/890	1050	1050	750/890	750/890	750/790	750/790	750

* During March through November in Moderately Dry and Dry type years, additional releases will be made as necessary to provide flows, above the 750 cfs anticipated to be diverted by the Redlands Water and Power Company, for the fish ladder and fish screen as shown.

- **General**

Attachment 11 summarizes many of the general guidelines for operations that will continue under the proposed action.

2.2 Adaptive Management

Adaptive management is a systematic approach for improving resource management by learning from management outcomes. Adaptive management promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become understood. Essentially, the long-term responses of endangered fish to new operations and other Recovery Program actions are uncertain and future monitoring will be needed to make adjustments in implementing operations and the overall Recovery Program.

Uncertainties of endangered fish response to management actions exist throughout the Recovery Program and adaptive management principles are integral to addressing them. The Recovery Program acts both as a scientific clearing house on the technical side of adaptive management and as a vehicle for agencies (such as the state of Colorado, Western Area Power Administration, Reclamation, the Service, and others) to identify and coordinate research and monitoring in the presence of other stakeholders.

There are uncertainties related to the response of endangered fish populations and critical habitat to the flow modifications proposed under the preferred alternative for Aspinall Unit reoperation. For that reason, the Flow Recommendations Report (McAda 2003) suggested using adaptive management principles, including monitoring responses of fish and their habitat to the new flow regime, to address uncertainties.

Uncertainties identified in the Flow Recommendations Report by McAda (2003) include:

- Determination of the amount and location of floodplain habitat necessary for recovery of species.
- Determination of relationship of reproductive success of pikeminnow and humpback chub to increased spring flows. Effect of new flow regime on non-native fishes that adversely affect native fish.
- Determination of the frequency (recurrence interval) and duration (number of days) that flows need to exceed half bankfull and bankfull discharge to maintain habitats required by the endangered fishes.
- Determination of response of primary and secondary production in the rivers to new flow regime.
- Consideration of the trade-off between high spring flows and base flows needed during the mid-to late summer.

Other uncertainties include whether elevated selenium concentrations and other water quality elements affect the recovery of the endangered fish in the Gunnison and other basin rivers. As discussed in Section 3.4.3 of this PBA, the effect of selenium levels on fish recovery in the Gunnison and Colorado rivers is not clear. Long-term trends in selenium concentrations have not been determined. Clarifying these effects is a necessary first step in addressing these uncertainties.

Reclamation and the Service will work together and with the Recovery Program to develop study plans to evaluate endangered fish populations and their habitat and their response to the new flow regime. This coordination will occur within one year of the finalization of the biological opinion and Record of Decision on the reoperation. Reclamation and the Service will also work through the Recovery Program to implement the study plans**.** This would include (1) identifying appropriate monitoring and research to evaluate effects of Aspinall reoperation and (2) including these activities in the Recovery Program's RIPRAP as necessary to identify the potential for modifying or refining flows from the Aspinall Unit. These plans may include research-driven requests for flows to answer questions identified in the study plan.

New information developed by the Recovery Program from these activities will be presented to Reclamation to determine operational flexibility available to address the new information. It is expected that any refinements in operation of the Aspinall Unit would be within the scope of the current proposed action and that implementation of refinements would occur with appropriate Section 7 consultation as necessary.

2.3 Extreme Conditions, Maintenance, and Emergencies

Flow recommendations address dry years by basing peak flow and duration targets on annual inflow conditions. Also in severe drought years such as 1977 and 2002 no special peak releases are targeted for endangered fish. Dry year peaks are only 900 cfs. Severe droughts, with anticipated shortages to Aspinall Unit water uses, will be responded to through shortage sharing. Operational changes could include temporary modifications to normal operations of the reservoir and potential short-term modifications in the target flows in the proposed operation. In periods of extreme, multi-year droughts, releases from the Aspinall Unit may have to be reduced to match the inflow to the reservoir during part of the year.

The proposed action would include certain specific drought rules:

- In Wet, Moderately Wet, and Average Wet years following a Dry year in which the previous December 31 Blue Mesa content was less than 522,300 af and if March 31 content is less than 400,000 af, half bankfull targets are reduced to the next lower category.
- During Dry and Moderately Dry years, if Blue Mesa content drops below 600,000 af, Whitewater base flow target is reduced from 1,050 cfs to 900 cfs until Blue Mesa content exceeds 600,000 af.
- If a Moderately Dry year follows a Dry or Moderately Dry year, decrease peak target to 5,000 cfs if Blue Mesa content is less than 400,000 af on March 31 or April 30.

Operations at the Aspinall Unit may be modified due to special maintenance or replacement needs which may limit outlet capacities or require special downstream flows for repairs and inspections. Special flows may also be needed at some time in the future for repairs or replacement of the Gunnison Tunnel Diversion Dam, located a short distance downstream from Crystal Dam.

Emergencies are not predictable but may be associated with dam safety, personal safety of individuals or groups associated with recreation or other activities on the river, power system conditions, or releases of oil, hazardous substances, pollutants, or contaminants. Emergencies associated with dam safety could include unforeseen high or low releases or operations to protect dam structures. Emergencies with the safety of individuals may be associated with river rescue or recovery operations. Power emergencies could include insufficient short-term generation capacity, transmission maintenance, and other factors. Emergency operations are typically of short durations as a result of emergencies occurring at the dam or within the transmission network. In the case of emergencies, Reclamation will immediately address the problem and then comply with 50 CFR Section 402.05 emergency procedures.

2.4 Coordination of Operations

Reclamation will continue to conduct Aspinall Unit operations meetings 3 times per year. The purpose of operation meetings-- held in January, April, and August-- is to share information between Reclamation and Aspinall stakeholders regarding issues in the Gunnison Basin related to the operation of the Aspinall Unit. The meetings are used to coordinate activities among agencies, water users, and other interested parties concerning the Gunnison River. Reclamation considers the information exchange at these meetings in preparing operation plans for the Unit. The projected operation of the Aspinall Unit is used by Reclamation in the development of the overall 24-month Study, a comprehensive planning model for the operation of Reclamation projects in the Upper and Lower Colorado River Basins, and includes operating plans for Glen Canyon, Flaming Gorge, and Navajo Units, as well as the Aspinall Unit. Operation of the Aspinall Unit considers projected hydrologic factors, authorized unit purposes, existing water rights, target elevations for reservoirs, implementing the preferred alternative for endangered fish, and other factors.

Reclamation will communicate with appropriate agencies and organizations prior to scheduled operation meetings or as needed to gather information useful in developing proposed operation plans to be presented at operation meetings.

2.5 Other Elements of the Action

The proposed action includes the continuation of the operation of other Reclamation Projects in the Gunnison Basin as listed in Section 1.3. Operation of these projects would continue by water districts or associations under contract with Reclamation.

In addition, private, local, and state water projects and uses in the Gunnison Basin would continue. As with the Aspinall Unit, construction and past operations of facilities for these water uses is part of the environmental baseline and non-discretionary.

It is estimated that depletions from the Gunnison River above the Whitewater gage averaged 428,348 af over the 1975-2005 period (Reclamation 2008). Approximately 95% of these depletions result from irrigation and 5% from domestic and industrial water use and reservoir evaporation.

In this assessment, new depletions of 3,500 af, primarily in the North Fork Basin, are also addressed along with full development of the Dallas Creek Project (17,200 af) and use of 30,800 af of subordination water in the Upper Gunnison Basin. The new depletions of 3,500 af are not specifically identified but will most likely be related to residential development in the basin. Additional information on other water uses is found in Section 3.3.

In total, depletions under the proposed action would range in the 450,000-500,000 af. Table 5 summarizes the depletions under the proposed action.

Table 5. Estimated average annual depletions in the environmental baseline.

Project	Estimated average annual depletion (af)
Aspinall Unit	10,000
Uncompahgre Project	155,000
Dallas Creek Project	17,200
Paonia Project	10,000
Smith Fork Project	6,000
Bostwick Park Project	4,000
Fruitgrowers Project	4,100
Other water uses	210,000-260,000
Dolores Project	99,200*
Upper Gunnison Subordination	30,800 (maximum rather than average depletion)
Total for Gunnison Basin (excludes Redlands)	450-500,000 af

*The original Dolores Project ESA consultation addressed a 131,000 af depletion. Updated information indicates actual depletions are approximately 99,200 af. For ESA purposes, return flows to the San Juan Basin were considered depletions.

2.6 Conservation Measures

In addition to re-operating the Aspinall Unit, Reclamation will continue to support the Recovery Program and will continue to support efforts to improve water quality in the Gunnison River and downstream.

Public Law 106-392 authorizes the Bureau of Reclamation to provide up to $6 million per year (adjusted for inflation) of CRSP power revenues to partially meet the base funding needs of the Recovery Program and the San Juan River Recovery Program. Additional funding is provided by the participating States and the Service. Base funding provides for operation and maintenance of capital projects, implementation of recovery actions other than capital projects, monitoring and research to evaluate the need for or effectiveness of recovery actions, and program management to carry out the Programs. Reclamation will continue to support these activities as authorized by P.L. 106-392 as amended as well as subsequent legislation.

Adaptive management (Section 2.2) is considered a conservation measure and will allow flexibility in operations to respond to new information on the species.

A Selenium Management Program will also be developed that addresses potential selenium impacts on endangered fish species in the Gunnison and Colorado rivers (see Section 3.4.3 for potential effects). The Selenium Management Program will incorporate and continue ongoing selenium reduction efforts in the Uncompahgre Valley and other areas of the Gunnison Basin and will add several new elements to ensure the future effectiveness of the program. The overall long-term goal of the program is to assist in species recovery per the Recovery Goals. Elements of the Selenium Management Program include:

- Accelerated implementation of salinity/selenium control projects for irrigated agriculture
- Reduction of other non-point source selenium loading
- Technology development
- Water quality monitoring
- Monitoring of endangered fish populations
- Coordination with lower Gunnison River Basin watershed management plan
- Regulatory support
- Public information and education
- Adaptive management
- Institutional support

A final Selenium Management Program, including timeframes and goals, will be developed within 18 months of issuance of the programmatic biological opinion. This timeframe allows monitoring data and other information collected in the first year to be used to refine the plan. During this period, ongoing projects that reduce selenium will continue.

Reclamation's vision for the program involves a cooperative effort with the substantial involvement of stakeholders. Reclamation will request annual Federal funding subject to appropriations (in addition to existing Salinity Control Program funding under the Colorado River Basin Salinity Control Project [CRBSCP] Act). Keys to success are the support and participation of basin water users for selenium reduction measures and improved management of water and land resources. With limited Federal budgets, local support and participation are critical elements to achieving success.

The development of the Selenium Management Program will focus on the lower Gunnison River and will pay particular attention to the Uncompahgre Valley. The Selenium Management Program will involve the established Selenium Task Force participants, federal agencies, water users, and state, county, and local government agencies. Because the Program will involve many interests and parties, formal documentation and funding mechanisms will be developed over the 18 month period following issuance of the programmatic biological opinion by the Service. Implementation will begin immediately with completion of the programmatic biological opinion, and implementation of all aspects of the Selenium Management Program not already underway will begin within 5 years of issuance of the opinion for the Gunnison River Basin in accordance with a Long Range Plan to be prepared.

The Selenium Management Program Long Range Plan will include identification of specific cost effective selenium reduction measures, high priority implementation locations, implementation schedule, benchmarks, responsible entities, monitoring needs, and coordination with ongoing Recovery Program activities. The Selenium Management Program will define funding and other resources needed for implementation, including commitments by Reclamation, the State of Colorado, water users, local governments and other parties. The Long Range Plan will be formatted similar to the Recovery Program's Recovery Action Plan and will be updated annually. Progress in implementing the Long Range Plan will serve as the benchmark for evaluating progress in implementing the Selenium Management Program.

Implementation of a Selenium Management Program in the Lower Gunnison River basin will be based on the best available information that focuses actions toward the recovery of razorback sucker and Colorado pikeminnow. Initially, this means that efforts will be made to reduce selenium loading in a timeframe complimentary to Recovery Goal timelines for razorback sucker and Colorado pikeminnow.

The ultimate objective of this Program is to meet the Recovery Goals for razorback sucker and Colorado pikeminnow (2002; currently being updated by the FWS); thus, additional selenium reduction efforts may continue and expand per the Program timelines. Once self-sustaining, recovered populations per the Recovery Goals have been attained, further selenium reduction efforts could be discontinued as long as new agreements are developed to maintain the selenium remediation measures that had contributed to the recovery of the subject species.

The Selenium Management Program will include the elements described below:

A. Accelerated Implementation of Salinity/Selenium Control Projects for Irrigated Agriculture: The salinity/selenium control projects implemented to date are described in Section 3.4.3. Future implementation is described below.

It is anticipated that the majority of reductions in selenium loading will be accomplished via the CRBSCP, NRCS Environmental Quality Incentives Program (EQIP) and grant-funded Task Force activities. Continuing implementation of CRBSCP projects is dependent on a competitive selection process. Uncompahgre Project proposals in the area of most concern are expected to remain cost competitive; however, more costly projects may require supplemental funding.

In the past, supplemental funding for Uncompahgre Project irrigation system improvement proposals was provided by the National Irrigation Water Quality Program (NIWQP), Congressional "write-ins" for selenium control, and EPA Section 319 funding. As shown in Table 5 in Section 3.4.3, supplemental funding provided about $1 for every $2 from the CRBSCP for initial irrigation system improvements (Phases 1-4). Although this amount of supplemental funding has traditionally been required to make Uncompahgre Project lateral piping projects more competitive under CRBSCP, the Program's current competitive cost range is increasing and recent Uncompahgre Project proposals have been found to be cost effective absent supplemental funding.

In the future, supplemental funding to augment CRBSCP funding for the more costly canal lining and pipe replacement of large laterals will be provided by Reclamation, subject to appropriations, and may be further complimented by state funds and various grant funding opportunities. Reclamation will seek supplemental funding (subject to appropriation) to assist in implementing all facets of the Selenium Management Program. Portions of this funding will be used to implement agriculture-related projects as well as the other activities as described in items B through J below.

Three phases of salinity/selenium control projects have been implemented or are underway in the Uncompahgre Valley. The recently funded Phase 4 includes an additional 11.4 miles of lateral lining in high priority selenium reduction areas, bringing the total length of laterals completed or under contract to 51 miles. This phase is presently scheduled to be completed by 2012. Approximately $2.8 million will be available for implementation of Phase 4, $2 million from the Salinity Control Program and $800,000 from the Environmental Protection Agency's (EPA) 319 grant program. Phase 4 is expected to reduce salinity loading by 3,650 tons/years and selenium loading by 70 to 360 pounds/year.

It is anticipated that the development of the Selenium Management Program will include advanced planning to outline future CRBSCP proposals involving larger scale lateral piping and possibly canal lining projects in the Uncompahgre Valley that should provide more rapid selenium loading reductions to the lower Gunnison River. With approximately $2 million/year (in current dollars) for lateral piping, Uncompahgre Project managers estimate that they could install approximately 10 miles of laterals each year on the east side of the Uncompahgre Valley. This commitment, subject to appropriations, exceeds current average construction rate of 5 miles/year. With more dependable funding, equipment could be purchased and a crew could be working year around on installation of pipe. Given sufficient resources, it is estimated that all remaining laterals and small canals in the planned East Side (of Uncompahgre Valley)

Laterals Project could be piped in approximately 15 years or by 2024 if the biological opinion is completed in 2009. This additional 151 miles of pipeline will reduce salt loading by approximately 50,000 tons/year and selenium loading by 1,000 to 5,000 pounds/year at a total cost of $35 to $40 million (in current dollars). Canal lining in the highest selenium loading sub-basins will also be investigated in the development of the Selenium Management Program. Lining a major delivery canal such as the Selig Canal through the Loutzenhizer Arroyo drainage could be expected to reduce salinity loading by an additional 400 to 500 tons/mile/year and associated selenium loading by an additional 10 to 50 pounds/mile/year.

Other Lower Gunnison basin salinity/selenium projects, outside the Uncompahgre Project service area will be incorporated into the Selenium Management Program if determined to be viable and necessary.

In addition to increasing water delivery system efficiency by piping laterals and lining of canals, future salinity/selenium control measures will focus on a) increasing near-farm water delivery system efficiency by installing pipelines, b) increasing on-farm irrigation efficiency by installing high efficiency systems such as sprinkler and drip systems and c) encouraging other more efficient irrigation practices and measures to reduce deep percolation of water that results in reductions of selenium loading to the lower Gunnison River. This component will be accomplished via the NRCS EQIP and the recently created Basin States Salinity Control Program.

Reclamation will work with water providers, conservation districts and NRCS to promote on-farm salinity control projects to reduce seepage losses and deep percolation from irrigation practices in areas with known high selenium loading rates. To the extent possible, Reclamation will work with NRCS to prioritize the funding of EQIP projects in high selenium loading areas of the basin. Such targeted efforts have been documented to result in more cost effective non-point source control proposals by controlling ‘two contaminates for the price of one’. Utilizing this approach may further improve Lower Gunnison projects cost effectiveness under the CRBSCP.

Reclamation will support funding from any source that might accelerate selenium control efforts, consistent with applicable federal, state and local laws.

B. Reduction of Non-Point Source Selenium Loading from Developing Areas: To accelerate efforts to reduce selenium loading from urbanizing areas, Federal and State agencies and basin water users will enhance their level of participation in the Task Force. Reclamation and others will provide additional technical, financial, and administrative assistance so that the Task Force can achieve the following:

- identify and encourage implementation of Best Management Practices to minimize selenium loading to the lower Gunnison River associated with urban and suburban development activities;
- discourage the construction of unlined ponds and/or water features in pervious selenium rich soils;

- work with local governments, responsible for land use planning, to minimize new selenium loading by avoiding housing and industrial developments which utilize leach fields or outdoor irrigation in areas with high selenium loading potential, such as previously unirrigated lands;
- support local government requirements to convert irrigation delivery systems from open channel to piped systems in urbanizing areas;
- support local government implementation of development codes which encourage native landscaping, limit irrigated landscape areas, and/or require efficient landscape irrigation systems on selenium rich lands;
- increase educational programs for better understanding of selenium issues and acceptance of appropriate solutions; and
- support general water conservation programs for all outdoor water uses (lawns, golf courses, septic systems, etc.), including public education efforts to promote more efficient water use and minimization of deep percolation.

C. Technology Development: Reclamation will utilize its Science and Technology Program, to the extent possible, to explore new technologies for reducing selenium loading and/or remediating drainage water with elevated selenium concentrations. The technologies to be reviewed for feasibility include development of approved flocculating agents that can potentially be extremely cost effective and can be implemented quickly to reduce seepage and selenium loading, bioreactors, and other technologies to cost effectively treat selenium-rich waters.

D. Water Quality Monitoring: Federal, state and local entities will partner to monitor selenium concentrations in the lower Gunnison River and its tributaries in order to better understand selenium loading mechanisms, quantify selenium loading reductions and establish selenium loading trends over time.

Although, selenium concentrations in the lower Gunnison Basin have been monitored for years, current water quality monitoring for selenium on a regular basis is occurring only at two stations: Uncompahgre River at Delta (Colorado Department of Public Health and Environment, quarterly sampling) and Gunnison River near Grand Junction (USGS and Colorado Department of Public Health and Environment). Water quality monitoring for selenium has previously occurred at Gunnison River at Delta, Gunnison River below the Gunnison Tunnel, Uncompahgre River at Colona, and North Fork of the Gunnison River near Somerset.

The Colorado River Water Conservation District is working on a proposal to expand selenium and flow monitoring by installing real-time specific conductance monitors and gage stations to help define relationships between selenium and total dissolved solids. Proposed monitoring includes samples for major ions and dissolved selenium, as well as flow. The sites under discussion include:

- Gunnison River below Gunnison Tunnel (above selenium loading areas)
- North Fork of the Gunnison River at its mouth
- Gunnison River at Delta

- Uncompahgre River at Colona (above selenium loading areas)
- Uncompahgre River at Delta

Depending on the level of monitoring, cost estimates, exclusive of initial gage installation costs, range from $40,500-$118,000/year.

The Colorado River Water Conservation District is developing cost sharing arrangements. The resulting final monitoring program will be included in the Selenium Management Program.

E. Monitoring of Endangered Fish Populations: The Recovery Program experimentally stocked razorback sucker in the lower Gunnison River (i.e., downstream of Delta) during the mid-1990's and initiated an integrated stocking plan in 2003. Operation of the fish ladder at the Redlands Diversion Dam on the lower Gunnison River began in 1996 and restored access to 50 miles of critical habitat for the endangered fishes. The Recovery Program periodically conducts fish surveys in the lower Gunnison River. Over the past several years, those surveys have included sampling to determine if razorback sucker and Colorado pikeminnow are reproducing in the lower Gunnison River. Larvae of both species have been found, and survival of razorback sucker larvae through the first year is evidenced by collections of juveniles (it is uncertain whether these juveniles were stocked as larvae or produced from reproduction by stocked adults). The Recovery Program monitors the Colorado pikeminnow population in the Upper Colorado River Subbasin to develop population estimates for the purpose of tracking progress toward achieving the Subbasin demographic Recovery Goal criteria. This monitoring includes the Gunnison River downstream of the Redlands Diversion Dam and incorporates fish using the fish ladder.

The Recovery Program is developing a basin-wide razorback sucker monitoring program that will include monitoring of all life stages. Design of the monitoring program is expected to be completed in fiscal year 2009. Implementation will begin in 2010. It will include multi-life stage monitoring on the lower Gunnison River. Eventually, population estimates will be developed for razorback sucker that will include fish in the lower Gunnison River.

Results of future fish surveys, ongoing population estimates for Colorado pikeminnow, and the future monitoring program for the razorback sucker will provide the basis for determining the status of Colorado pikeminnow and razorback sucker in the lower Gunnison River. This information will be used to measure the success of recovery efforts and perhaps the effects of the Selenium Management Program and will be incorporated into the adaptive-management process to determine factors limiting recovery of Colorado pikeminnow and razorback sucker

F. Coordination with Lower Gunnison River Basin Watershed Management Plan: The Selenium Task Force is developing a Watershed Management Plan (WMP) for the lower Gunnison River Basin. The WMP will focus on remediation of selenium with the goal of meeting the 4.6 parts per billion (ppb) water quality standard. Any organization addressing remediation planning within the watershed may utilize the WMP for planning purposes. The objective of the WMP, once adopted, is to guide, direct, and prioritize 319 Grants from EPA to specific projects within the watershed. The WMP will identify causes and sources of water quality impairment, estimate load reductions, and describe nonpoint source management measures, identify technical and financial assistance needed to carry out the WMP, provide an implementation schedule, define an education and outreach program, develop milestones for determining progress, set criteria to measure selenium load reductions, and develop a monitoring program to determine effectiveness of implementation efforts.

The Task Force will complete the watershed management plan by September 1, 2010. WMP development is supported by 319 Grant funds ($32,479) and local matching funds ($23,020). Development of the WMP will guide and direct future 319 Grants to high priority selenium reduction areas in the Gunnison Basin and provide a source of funding for a number of activities in the Selenium Management Program.

G. Regulatory Support: Reclamation will consider selenium loading as a factor in its NEPA/ESA review of any proposed new irrigated lands associated with Reclamation projects in the basin. The Bureau of Land Management will be encouraged to fully consider possible ramifications of any land transfers or exchanges on selenium loading and implement restrictions where any increases are possible.

H. Public Information and Education: Reclamation will provide staff support for implementation of a public information and education element as part of the Selenium Management Program.

I. Adaptive Management: An adaptive-management component will be described in the final Selenium Management Program. It will include annual review of progress and reporting to the Service, annual updating of the Long Range Plan, a periodic review of the effectiveness of ongoing selenium reduction measures, water quality monitoring data, and status of endangered fish, followed by adjustments in the Selenium Management Program as needed. To ensure transparency, the process will be formalized in terms of timing of reviews, procedures, and development of reports for publication that include recommendations for modification of the Selenium Management Program as needed.

J. Institutional Support: Development and implementation of the Selenium Management Program and its associated Long Range Plan is a significant responsibility. There will be a need for oversight of the implementation of the Selenium Management Program and the Long Range Plan, annual update of the Long Range Plan, coordination of activities, reporting of progress on Selenium Management Program implementation, and coordination of the adaptive management process. It is recommended that the Task Force assume a significant share of responsibilities, with substantial institutional and financial assistance from Reclamation, Colorado River Water Conservation District, State of Colorado, the Service, and other parties involved in the Task Force.

Reclamation will have primary responsibility for development of the Selenium Management Program and the Long Range Plan. Coordinating implementation of the Selenium Management Program and Long Range Plan is recommended to be the responsibility of the Task Force. The Task Force would have ongoing responsibilities for tracking implementation of the Long Range Plan, agreements and attainment of funding. The Task Force – and its staff – would not be responsible for implementation of the Selenium Management Program, but would have responsibilities for oversight, monitoring, and reporting. In addition, the Task Force would be responsible for facilitating modifications to the Selenium Management Program and the Long Range Plan, based on recommendations developed through an adaptive management process.

Reclamation will be responsible for implementation of the piping of laterals, subject to appropriations. Reclamation will also be responsible for implementation of more costly canal lining and pipe replacement of large laterals should the Selenium Management Program determine these methods effective. Reclamation will implement effective selenium reduction subject to appropriations and supplemental funding provided by state and grant programs.

2.7 Authority

The PBA is prepared in accordance with Section 7 of the ESA of 1973, as amended (16 U.S.C. 1531et seq.).

The following paragraphs describe the Department of the Interior's basis and authority for implementing the new operations at the Aspinall Unit. The authority to implement the operations is found in Section 1 of CRSPA. This section states:

> In order to initiate the comprehensive development of the water resources of the Upper Colorado River Basin, for the purposes, among others, of regulating the flow of the Colorado River, storing water for beneficial consumptive use, making it possible for states of the Upper Basin to utilize, consistently with the provisions of the Colorado River Compact, the apportionments made to and among them in the Colorado River Compact and the Upper Colorado River Basin Compact, respectively, providing for the reclamation of arid and semi-arid land, for the control of floods, and for the generation of hydroelectric power, as an incident of the foregoing purposes, the Secretary of the Interior is hereby authorized (1) to construct, operate, and maintain the following initial units of the Colorado River storage project, consisting of dams, reservoirs, powerplants, transmission facilities and appurtenant works…

The Colorado River Compact of 1922 established an Upper Basin and a Lower Basin within the Colorado River system and apportioned the exclusive beneficial consumptive use of Colorado River water in perpetuity to the Upper and Lower Basins. The Upper Colorado River Basin Compact of 1948 apportioned the Upper Basin's share of the Colorado River system among the states of Colorado, Utah, Arizona, Wyoming, and New Mexico. CRSPA was enacted in 1956 to facilitate the development of the water and power resources of the Upper Basin consistent with the Compacts.

The Recovery Program (Section 2.8) was developed to facilitate the continued development of states' Compact apportionments in light of ESA concerns. The goal of the Recovery Program, therefore, is to conserve the Gunnison and Colorado rivers populations of endangered fish species consistent with the recovery goals of the species published by the Service, while proceeding with the continued operation and development of water resources of the Colorado River Basin. All Recovery Program participants, agreeing that recovery to the point of de-listing will both facilitate and insure the continued development of water resources, have agreed with the principles and goals of the Recovery Program through their participation in and support of program activities. In addition to its recovery objectives, the Recovery Program includes an agreement on principles for conducting ESA Section 7 consultations, wherein program actions and sufficient progress toward recovery constitute a Reasonable and Prudent Alternative for existing and future water resource management and development activities that are likely to jeopardize the continued existence of endangered fish species or cause the destruction of or adverse modification of critical habitat of those species.

The Flow Recommendations for the Gunnison River, in concert with other program actions, are intended to avoid jeopardy and assist in recovery. By implementing actions that assist in meeting the Flow Recommendations, Reclamation is taking the steps necessary to avoid jeopardizing the continued existence of the endangered fish from the operation of the Aspinall Unit and to voluntarily and cooperatively take steps to facilitate recovery of the fish, which, in turn, will support the continued and further utilization of the Federal facilities to aid in the development of the states' Compact apportionments. Thus, consistent with the authorized purposes of CRSPA, implementation of the proposed action supports the States in the utilization of their Compact apportionment while assisting in the recovery of endangered species. Moreover, that specific authorized purposes of the Aspinall Unit may not be fully maximized for limited durations in certain year types does not invalidate the actions of the Secretary, as long as the overall purposes of CRSPA are met and we expect in this instance, these purposes will be met.

This action is limited to the proposition that both avoiding jeopardy and making progress toward recovery of listed fish facilitate the ability of the Upper Basin states to continue utilizing and further developing their Colorado River apportionments. In these particular and unique circumstances, therefore, we conclude the implementation of an operations regime that is consistent with the proposed alternative is deemed to be within the authorization contained in Section 1 of CRSPA.

2.8 Upper Colorado River Endangered Fish Recovery Program

The Recovery Program involves federal, state, and private organizations and agencies in Colorado, Utah, and Wyoming with a common goal of recovering endangered fish and providing for present and future water uses in the Upper Colorado River Basin. The program involves several elements:

- Improving river habitat-protecting and improving floodplains, constructing fish passages, installing fish screens in canals
- Conducting research-studying the fish and their habitat, monitoring
- Providing adequate streamflows-manage releases from upstream reservoirs, improve efficiency of existing uses, modify timing and magnitude of releases from major reservoirs
- Managing non-native fish species-stocking agreements, control escapement from reservoirs, remove selected species from critical habitat
- Stocking-establish hatcheries and growout ponds, establish refugia ponds, reestablish populations

In cooperation with the Recovery Program, Reclamation has operated the Aspinall Unit to provide research flows in the lower Gunnison River. Research and monitoring studies have been completed on the Gunnison River, including biological investigations, river morphology studies, and water temperature studies. Monitoring of endangered fish populations and reproduction and recruitment are continuing. Habitat studies continue through U.S. Geological Survey sediment movement studies. A fish ladder has been constructed around the Redlands Diversion and a fish screen installed in the Redlands Canal. Water has been supplied to operate the fish ladder and screen. Backwater improvements and protection and floodplain conservation easements have been made near Delta and Whitewater and are monitored; and Colorado pikeminnow and razorback suckers have been stocked in the Gunnison and this stocking will continue.

In addition studies have been completed on the Colorado River in Colorado and Utah and on its major tributaries, and backwater improvement/ protection and fish passages and fish screening have been completed. Research, stocking and monitoring programs continue.

In order to define and clarify processes of the Recovery Program, a Section 7 Agreement and a Recovery Implementation Program Recovery Action Plan (RIPRAP) were developed (Fish and Wildlife Service 1993) and updated annually. The Agreement established a framework for conducting Section 7 consultations on depletion impacts related to new projects and impacts associated with existing projects in the Upper Basin. Activities and accomplishments under the Recovery Program are intended to provide the reasonable and prudent alternatives which avoid the likelihood of jeopardy to the continued existence of the endangered fish resulting from depletion impacts of new projects and all existing or past impacts related to historic projects with the exception of the discharge by historic projects of pollutants such as trace elements, heavy metals, and pesticides.

Procedures outlined in the Section 7 Agreement are used to determine if sufficient progress is being accomplished in the recovery of endangered fishes to enable the Recovery Program to serve as a reasonable and prudent alternative to avoid the likelihood of jeopardizing and/or adversely modifying critical habitat. The RIPRAP presents specific recovery actions such as providing instream flows, constructing and operating fish passages and fish screens, controlling non-native fishes, and propagating and stocking endangered fish. The Gunnison River portion of the Recovery Plan includes 63 individual actions, 78% of which are completed or ongoing. One remaining high priority action is to operate the Aspinall Unit to improve conditions for downstream endangered fish.

2.9 ESA Consultation History

Consultation on the operation of initial units of the Colorado River Storage Project was deferred in the 1980's pending completion of hydrologic, biological, and other studies. Construction of the units occurred prior to passage of the ESA. At the present time, consultations have been completed on the operations of Flaming Gorge Dam and Reservoir and Navajo Dam and Reservoir and operations of these features have been modified to improve habitat conditions of the endangered fish.

There are several ESA consultations related to the present Aspinall Unit consultation and the Gunnison Basin:

> Dallas Creek Project Biological Opinion--"The most serious problem posed by the Dallas Creek Project and related water developments is the loss of water from the Gunnison River and the Colorado River. We know of only one alternative which would allow the proposed project to be constructed and operated without jeopardizing the Colorado squawfish and the humpback chub. That alternative is the release of water from the Dallas Creek Project or from other projects that regulate flows in the Gunnison River and the Colorado River in order to replace the depletions caused by the Dallas Creek Project. This released water could provide for essential life stages of the endangered fishes. The Curecanti (Aspinall Unit) Project may be the best source of water for such releases….The Dallas Creek Project would deplete 17,200 acre-feet of water in an average year. To compensate for this loss of water from the river system, it may be necessary that an equal volume be released to the Gunnison River from one or more projects…However, our studies may reveal that flow releases totaling less than 17,200 acre-feet annually are adequate for the fishes to survive in the areas and in the numbers that we believe necessary for recovery" (Fish and Wildlife Service 1979).

> Dolores Biological Opinion--"…only one alternative which would allow the proposed project to be constructed and operated without jeopardizing the Colorado squawfish, humpback chub, and the bonytail chub. That alternative is the release of water from the Dolores Project, or from other projects that regulate flows in the Colorado River, to replace the depletions caused by the Dolores Project. …..The Dolores Project would deplete 131,000 acre-feet of water in an average year. To compensate for

> this loss of water from the river system, it may be necessary that an equal volume be released to the Colorado River from one or more projects. This alternative would prevent the Dolores Project itself from jeopardizing the existence of the fishes of concern…We are intensively studying the endangered Colorado River fishes, but at present we cannot recommend specific flows that should be released. However, our studies may reveal that flow releases totaling less than 131,000 acre-feet annually are adequate for the fishes to survive in the areas and in the numbers that we believe necessary for recovery" (Fish and Wildlife Service 1980).

The original depletion estimate for the Dolores Project, 131,000 af, included downstream releases for the trout fishery. This release is at least 31,097 af and was incorrectly considered a depletion. Thus the present estimated depletion for the Dolores Project is no more than 99,200 af above Lake Powell.

Since the Dallas Creek and Dolores Projects' opinions were written, the Upper Colorado River Recovery Program has been established. Reclamation has also had informal conversations with the Service on how to address the above opinions. The goal of Reclamation and the Service during these discussions was to arrive at a proposed alternative that offsets the impacts of Dallas/Dolores depletions and satisfies the biological opinions on those projects. At the present time the full depletions from the Dallas Creek Project have not been realized; full depletions for Dolores are occurring but, as indicated above, the original depletion estimate was higher (approximately 30,000 af) than what is actually occurring under full depletion.

Upper Gunnison Subordination Agreement—The Fish and Wildlife concurred with a "no effect" determination for impacts to the downstream endangered fish based on two conditions: "1) The 60,000 acre-foot depletion will be consulted on during the upcoming Aspinall Unit consultation; and 2) During the interim, all actions that deplete water out of the 60,000 acre-foot block will be considered new projects and consulted on as we have done in the past." (Fish and Wildlife Service 1999)

Minor water sales—Sixty nine ESA consultations totaling less than 1,000 af of minor water sales have been made from the Aspinall Unit and have received biological opinions, citing the Recovery Program as the reasonable and prudent alternative to avoid jeopardy to the endangered fish due to the depletions. These sales are primarily for augmentation water.

Redlands Canal Fish Screen Biological Opinion—In this opinion (Fish and Wildlife Service 2004), the following conservation measures were included. The opinion identified the Recovery Program as the reasonable and prudent alternative.

> "Reclamation will to the extent allowable under State and Federal law, attempt to release from the Aspinall Unit sufficient water to maintain a

minimum flow of 300 cubic feet per second (cfs) during the months of July August, September, and October in the Gunnison River from the Redlands Diversion to the confluence of the Gunnison River with the Colorado River. Said flows include water necessary to maintain fish access to critical habitat in the Gunnison River below Redlands Diversion for authorized fish and wildlife purposes (providing suitable endangered fish habitat). During periods of drought when the 300 cfs below Redlands cannot be met, Reclamation will work with the Service and water users to attempt to maintain flows lower than 300 cfs below Redlands for endangered fish. The operation will remain in place until the Aspinall Operations Environmental Impact Statement is complete and Reclamation has issued a Record of Decision on Aspinall Operations to address endangered fish flows in the Gunnison and Colorado Rivers. Operations developed through the environmental impact statement and Endangered Species Act Section 7 consultation process will address long term flow requirements below the Redlands Diversion.

15-Mile Reach Programmatic Biological Opinion (Fish and Wildlife Service 1999b)—This biological opinion addressed the continuation of Reclamation operations and depletions in the Upper Colorado River Basin above the confluence with the Gunnison River; Reclamation's portion of 120,000 af/year of new depletions in the same area; and recovery actions in the Colorado River.

Paonia Project Biological Opinion (Fish and Wildlife Service 2002b)—This opinion, related to a temporary water service contract using temporary capacity in the sediment pool of Paonia Reservoir, calls for a portion of the water in the surplus capacity to be released during the spring spill period of the reservoir.

The Service has consulted on approximately 330 water projects/uses in the Gunnison Basin upstream from the Redlands Diversion. These projects included 11,918 af of new depletions and 171,148 af of existing depletions.

3.0 ENVIRONMENTAL BASELINE

3.1 Baseline

For purposes of this PBA, an environmental baseline was developed which includes the past and present impacts of all Federal, State, and private actions and other human activities in the action area; the anticipated impacts of all proposed projects in the action area that have already undergone formal Section 7 consultation under the ESA; and the impact of State or private actions contemporaneous with the consultation process. This baseline is a "snapshot" of species' health at a specified point in time. Under this baseline, the decision to construct the Aspinall Unit for Congressionally authorized purposes and the decisions to build and operate other basin water projects are past federal, state, or private actions, and by definition, they are part of the baseline.

This chapter provides a description of what is in the baseline, a description of baseline aquatic resources and geomorphology, and a description of baseline Aspinall Unit operations.

3.2 River Geomorphology

The Gunnison River is an alluvial, gravel-bed river in reaches important to the endangered fish. In general, changes in the river such as reduced peak flows, bank protection, and other factors which occurred in the 19th and 20th centuries reduced floodplain connectivity and simplified main-channel habitats.

Sediment inflow under pre-development conditions is unknown; however, it may have been considerably less than at present. It is possible that sediment inflows increased markedly around the beginning of the 20th century due to uncontrolled grazing, mining and timber harvesting and initial development of irrigated lands. Under baseline conditions, sediment inflow to the river has not significantly changed since construction of the Aspinall Unit. A large portion of the total sediment load now consists of silt and clay while bed load consists of sand and gravel-sized sediment. Pitlick et al. (1999) concluded that the key factor in maintaining river habitats was to assure that sediment entering critical habitat continues to be carried downstream so it would not accumulate and reduce channel complexity.

Present sediment inflows to the Gunnison River are significant. While spring peak flows have decreased in the river, sediment inflow to the river apparently has not (Pitlick et al. 1999, Pitlick and Cress 2000) because major sediment sources are downstream from the Aspinall Unit. Pitlick et al. (1999) estimated that the annual sediment load carried all the way through the Gunnison River dropped by more than 40% from 1964 to 1978—the net effect of this would be accumulation of sediment in the river channel causing a loss of channel complexity. Pitlick also noted that between 1979 and 1993 the annual sediment load of the river returned to pre-1964 conditions. Pitlick found that a given incremental increase in flow has a much greater effect on sediment movement at higher flows than at lower flows based on his work on the Colorado River.

Because the Gunnison River has a gravel bed and large-scale changes in the geomorphology of rivers generally come about only as a result of significant bed load transport, large floods are needed to create significant areas of new habitat. More moderate flows can maintain habitats, however.

Geomorphologists identify two important phases in sediment transport: initial motion and significant motion. Initial motion is the level that begins to remove fine sediments from the channel, including the interstitial spaces. Significant motion is characterized by continuous movement of most particles in the channel. Pitlick and Cress (2000) found that in the Gunnison River initial motion occurs at approximately half bankfull discharge and significant motion occurs at approximately bankfull discharge. “Flows equal to or greater than half bankfull are needed to mobilize gravel and cobble particles on a widespread basis, and to prevent fine sediment from accumulating. …Bankfull flows are sufficient to fully mobilize the bed material and thereby maintain the existing bankfull hydraulic geometry (Pitlick et al. 1999)."

In addition to the magnitude of flows, the duration of the flow is important in sediment transport. Based on field observations, Pitlick et al. (1999) recommended that to maintain habitat conditions, half bankfull and bankfull flows should occur with a long-term average equal to what occurred during 1978-1997. To improve habitat conditions the two threshold flows should occur with a long-term average equal to what occurred during 1993-1997. Required duration may best be determined through long-term monitoring.

Median values for initial and significant motion in various reaches of the Gunnison River between Delta and the Redlands Diversion were calculated to be 8,070 cfs and 14,350 cfs based on 54 cross sections. Initial motion begins at one site at 4,660 cfs and occurred at all 54 sites at 12,700 cfs. Bankfull motion begins at one site at 7,352 cfs but is not reached in the entire river until flows exceed 28,719 cfs (Pitlick et al. 1999). Table 6 provides information on the percentage of river cross sections that reach initial and bankfull motion at various river flows. Attachment 4 provides more detailed information on flow levels needed to reach half and bankfull levels at all 54 cross sections.

Based on Pitlick et al.'s (1999) work and using gage data available between 1897 and 1965, the frequency of years where half bankfull flows occurred dropped from 76 % pre-Aspinall Unit to 44 % post-Aspinall Unit. Frequency of bankfull years dropped from 45 % to 6 %. In addition the average number of days per year that flows of 8,070 occurred dropped from 26.6 to 14.5; the range changed from 0-71 to 0-74 days. For flows of 14,350 cfs or more, average number of days per year dropped from 6.5 to 2.5 and the range changed from 0-35 to 0-29 days.

Milhous (1998) conducted an intensive river morphology study on a 1-mile reach of the Gunnison River near RM 38. Twenty cross sections were established in the 1-mile reach. Based on measurements over a 3-year period several sediment transport levels were estimated:

- Flush fine sediments from the surface of the bed – 12,535 cfs
- Remove gravel from pools – 17,000 cfs
- Scour side channels – 7,415 cfs
- Prevent fine sediments from being deposited on riffles where spawning would occur – 950 cfs.

Table 6. Gunnison River: percentage of cross sections reaching initial motion and bankfull thresholds at various flows in critical habitat reach.

Flow (cfs)	Percentage of cross sections reaching thresholds	
	Initial Motion (half bankfull)	Significant Motion (bankfull)
5,000	7	0
6,000	19	0
7,000	33	0
8,000	46	2
8,070	50	2
9,000	69	4
10,000	81	6
11,000	81	13
12,000	94	26
13,000	100	28
14,000	100	46
14,350	100	50
15,000	100	61
16,000	100	67
20,000	100	81

Differences between the Milhous and Pitlick studies result from large bed material in Milhous's study reach. The flow level Milhous determined for preventing fine sediments from being deposited in riffle areas is important during spawning periods to prevent fines from smothering embryos or eggs that might be deposited in the gravels.

Pitlick (1999) also estimated initial motion and bankfull flows for a Colorado River reach downstream from the Gunnison River represented by the Colorado-Utah stateline gage. Initial motion was estimated at 18,538 cfs and bankfull flow at 34,957 cfs. The frequency of years that initial motion was reached decreased from 71 % to 61 % between the pre- and post-Aspinall periods. The frequency of years that bankfull flow was reached decreased from 29 % to 21 %. These changes would reflect water developments in the upper Colorado River in addition to Aspinall Unit operations.

3.3 Past Water Uses and Reservoir and River Operations

Early water uses in the Gunnison Basin were for mining and irrigation. By 1900, most of the readily available sources of irrigation water had been developed by private individuals and small irrigation companies (Colorado Water Conservation Board 1962). Prior to the 1960's, Taylor Park Reservoir was the largest regulating reservoir in the basin, although there were numerous smaller reservoirs on Grand Mesa and elsewhere. By 1960, agricultural water depletions in the basin were estimated at 312,000 af (Colorado Water Conservation Board 1962) and there were additional depletions from domestic uses and reservoir evaporation.

In the 1960-1990 period, several moderately sized reservoirs (Table 1) were constructed in the basin including Ridgway, Paonia, Crawford, and Silver Jack.

The Aspinall Unit was constructed in the 1960-1980 period. Primary water storage at the Aspinall Unit occurs in the uppermost and largest reservoir, Blue Mesa. Water can be released from the reservoirs through the powerplants and/or river outlets (bypasses). As designed, spillway use is limited to periods when the reservoirs have reached high contents. Spillway use at Blue Mesa and Morrow Point is very infrequent. Due to the relatively small powerplant/bypass capacity at Crystal Dam, spills occur more frequently. In general, operation of the Aspinall Unit has changed the natural river flow pattern by storing spring peak flows and increasing flows during the remainder of the year. The effect of these past operations is included in the environmental baseline.

Table 7 summarizes statistics on the Aspinall Unit facilities.

Table 7. Aspinall Unit statistics.

Capacities (acre-feet)	Blue Mesa	Morrow Point	Crystal
Dead storage	111,200	165	7,700
Inactive storage	81,070	74,905	4,650
Active storage	748,430	42,120	12,890
Live storage*	829,500	117,025	17,540
Total storage	940,700	117,190	25,240
Outlet capacities (cfs)			
Powerplants (max)	2,600-3,400	5,000	2,150
Powerplant bypass	4,000-5,100	1,400-1,600	1,900-2,200
Combined powerplant and bypass(max)	6,100	6,500	4,350
Spillway	34,000	41,000	41,350

*-Live storage is the combination of the active and inactive storage. It represents storage that physically can be released from the reservoir.
-Blue Mesa Reservoir shares one penstock for both river outlet and powerplant releases; the combined releases of these two are constrained to about 6,100 cfs.
-The hydraulic capacities shown in the table assume full reservoir conditions. At lower elevations, the hydraulic capacity would be less. Also system efficiencies may affect the hydraulic capacity.
-Full capacity may not always be available due to scheduled maintenance, equipment malfunction, or power system reserve requirements.
-There are no specific recreation or fishery pools in the reservoirs.

Reclamation manages water at the Aspinall Unit within certain sideboards that include annual snowpack conditions, downstream senior water rights, minimum downstream flow requirements, powerplant and outlet capacities, reservoir elevation goals, fishery management recommendations, dam safety considerations, and others. Certain sideboards are non-discretionary such as honoring senior water rights and flood control, while others such as reservoir elevation criteria to reduce landslides are given a high priority

To conserve water for later use and to provide drought protection, an operational goal is to fill Blue Mesa. Full reservoir is 7,519.4 feet; however, operations are designed to reach around 7,517 feet (or less, dependent on forecast) which provides a safety factor for controlling the reservoir in case of sudden high inflow events due to heavy rains or high rate of snowmelt. Another operational goal is to draw Blue Mesa down to an elevation of 7,490 by December 31st to reduce the chance of ice jams and associated flooding upstream.

The five generators at the three dams of the Aspinall Unit are capable of generating up to 283 megawatts of electricity. Morrow Point has the largest capacity—its generators produce more than twice as much electricity as those at Blue Mesa. The Western Area Power Administration (Western) markets electricity generated by the Aspinall Unit in conjunction with power from Glen Canyon and Flaming Gorge Dams and other plants of the Colorado River Storage Project as part of an integrated system that provides electricity to all states of the Colorado River Basin. The upstream powerplants of the Aspinall Unit (Blue Mesa and Morrow Point) are critical in that they are operated to provide load following and peaking power. Crystal Reservoir then is committed as a regulation reservoir to stabilize releases to the Gunnison River. Peaking operations at Blue Mesa and Morrow Point help meet demands for electricity that change on an hourly, daily, and weekly basis.

The environmental baseline includes Aspinall Unit operational conditions before efforts were made to "bundle" surplus or risk of spill water into spring peaks for endangered fish. Spills and bypasses occur under the baseline; however, there is no effort to manage this water for specific endangered species needs. To the extent possible, water forecasted to be spilled or bypassed is released early in the year through the powerplants. Essentially, under the environmental baseline the Aspinall Unit is operated to maximize water storage and hydropower production, and minimize flow variations in the Gunnison River downstream from Crystal Dam.

Baseline hydrology conditions are discussed in Section 3.4 of the assessment while baseline conditions of listed species are presented in Section 4.0. Under the baseline:

- Existing spring flood control operations are continued (using discretion and being proactive to maintain flows below 14,000 cfs or normally considerably less at Delta [Delta City area above the Uncompahgre confluence]). Flood control operations would continue to be coordinated with the city and county of Delta. The Corps of Engineers flood control manual requires that efforts are made to keep flows below 15,000 cfs.

- Blue Mesa winter icing elevation target--7490 feet at end of December—is met to reduce chances of ice jams causing upstream flooding in the Gunnison area, for example in the Dos Rios subdivision area.

- Peaking power operations conducted at Morrow Point and Blue Mesa continue with flows downstream from Crystal regulated through uniform releases to offset impacts of peaking operations upstream. Blue Mesa releases range from 0 to 3,400 cfs and Morrow Point releases from 0 to

5,000 cfs. During Crystal spills, variations in Morrow Point peaking releases are reduced to avoid large daily fluctuations downstream from Crystal.

- Operations continue to meet 300 cfs downstream from the Gunnison Tunnel except in certain cases of significant drought (as determined by reservoir elevation projections) and during Aspinall Unit emergencies when flows may be reduced to 200 cfs as measured at the USGS Gage below the Gunnison Tunnel. Such a decision would be made only after coordinating with the State of Colorado and other interested parties.

- Morrow Point and Crystal Reservoirs' daily fluctuations are limited by landslide criteria.

- Existing contracts and agreements are honored; these documents include provisions for operations in extreme conditions of drought and flooding. There is discretion for operations during emergencies, regular maintenance activities, and extraordinary maintenance.

- Existing water and power contracts from the Aspinall Unit are part of the baseline (note that CRSP power contracts are not "unit specific" but apply to integrated project facilities). Water contracts have flexibility under water shortage conditions.

- The baseline continues to meet power system requirements of the North American Electrical Reliability Council and the Western Electricity Coordinating Council such as generation control, voltage regulation, black start capability, and reserves. For example, Aspinall Unit operations--such as Morrow Point peaking--can be used in emergency situations to prevent major power problems in the West.

- Consistent with authorized purposes, the Aspinall Unit is operated subject to water laws and water rights as decreed under Colorado water law and the Law of the River.

- Existing depletions in the Gunnison River Basin from the exercise of private and public water rights under Colorado law (including evaporation, diversions, transpiration, etc) continue as part of the baseline.

- The estimated portion of the 60,000 af subordination (Aspinall rights subordinated to water uses in the Gunnison Basin upstream from Crystal Dam) being used at this time (8,600 af in place now).

- For purposes of the environmental baseline, it is assumed that projected water uses with completed ESA and NEPA compliance are occurring. This would include full Dallas Creek Project depletions (and Dolores

Project depletions which are now fully developed from the Dolores River) and also include existing contracts with the Upper Gunnison Water Conservancy District and with private and public water users for Blue Mesa water.

- The baseline recognizes that one of the purposes of the Aspinall Unit is "…storing water for beneficial consumptive use, making it possible for the States of the Upper Basin to utilize, consistently with the provisions of the Colorado River Compact, the apportionments made to and among them in the Colorado River Compact and the Upper Colorado River Compact, respectively…".

  This use is compatible with the Recovery Program which has a goal of fish recovery and water development. Under the proposed action, "remaining project yield" (not precisely known, but approximately 300,000 af minus subordination water use and existing water contracts) will continue to be stored or go downstream on an interim basis and be modeled as such. It will be recognized that this remaining water may very well be developed in the future, upstream or downstream from the Unit, pursuant to the Colorado River and Upper Colorado River Basin Compacts, and subject to and consistent with the Unit's authorized purposes and other applicable laws. The State of Colorado has identified significant needs through the State Water Supply Initiative process and has significant consumptive use depletions remaining for use under the Colorado River Compact of 1922 and the Upper Colorado River Basin Compact and a portion of this would legally be available for development using sources in the Gunnison Basin. The unused portion of the Unit yield would not be relied on as part of any permanent solution that seeks to provide releases for flow recommendations or any subsequent modifications to them.

  The potential use of remaining Unit yield is not modeled because specific foreseeable proposals are not available. Alternative would recognize that consumptive use up to a total of 300,000 af of project yield may be used in the future under Colorado's compact entitlements and its use would not be precluded by the proposed action. When future water sales or uses of portions of the "remaining project yield: from the Unit are proposed, the proposals will be evaluated under NEPA.

  If Reclamation determines the proposed sale or use may adversely affect a listed species, ESA consultation will commence. If the Recovery Program has made sufficient progress implementing the Recovery Action Plan, then implementation of the Recovery Program may serve as reasonable and prudent measures or reasonable and prudent alternatives, as appropriate. The Section 7 consultation, sufficient progress, and historic projects agreement for the Upper Colorado River Basin Recovery Implementation

Program, as revised in 2000, provides information on ESA compliance for future projects, such as use of Aspinall Unit yield.

- The baseline includes Taylor Park 1975 and 1991 Agreements and the Taylor Park refill right in place. Up to approximately 100,000 af of Taylor Park water may be stored in Blue Mesa at any given time. Aspinall Unit is operated to protect Uncompahgre Project water stored in Blue Mesa under the Taylor Park Exchange Agreement. The Uncompahgre Project's Gunnison Tunnel and Dallas Creek Project's Ridgway Reservoir exchange continue in place.

- As a general guide, individual flow changes downstream from Crystal are planned to be the greater of 500 cfs or 15 % of flow when ramping up and the greater of 400 cfs or 15 % of flow when ramping down. Higher rates may be used to react to special circumstances, for example for flood control and emergencies or when canyon flows exceed 2,000 cfs.

- Gunnison Gorge flow decreases that could damage brown trout redds after October 15th are avoided when practical. Flow decreases or rapid flow changes are avoided after April 15th for rainbow trout spawning when practical.

3.4 Hydrology and Water Quality

3.4.1 Modeling

The baseline and the proposed changes in storage and release from the Aspinall Unit were modeled. The scope of the model encompasses the Gunnison River Basin from Blue Mesa Reservoir to the confluence with the Colorado River. RiverWare, a software modeling tool developed by CADSWES (University of Colorado) for the Bureau of Reclamation and the Tennessee Valley Authority for operations and planning studies of river basins and river systems, was used. The daily planning model, developed for initial analysis in 2002-2003 was updated in 2007. Various operations of the Aspinall Unit were modeled. The modeling period originally utilized a single 26-year trace from January 1975 through December 2000. The modeling period for this new analysis has been extended through December 2005 and now consists of a single 31-year trace. The model is used as a comparison and planning tool. The proposed action was modeled to determine river flows for the 1975-2005 study period and these flows were compared to modeled baseline flows. Results of modeling estimate conditions as if the baseline or proposed action were in place during the 1975-2005 period. Results are a general prediction of future conditions under the baseline or proposed action; however, actual future hydrology conditions will depend largely on future weather conditions. Additional information on modeling is found in Attachment 12.

3.4.2 River Flows

Table 8 presents modeled baseline peak flows and average monthly flows for the period of study at the Whitewater gage assuming the Aspinall Unit and other water projects in place and operating.

Table 8. Baseline river flows (average monthly cfs), Gunnison River at Whitewater, for period of record used in Biological Assessment analysis assuming Aspinall Unit and other water projects and uses in place and operating.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Peak daily mean for Year
1975	766	751	1326	3`93	6385	5467	3589	1937	2082	1993	1683	1650	8927
1976	1226	1286	1121	1678	3429	2484	1721	1120	1524	1628	1122	858	5130
1977	880	771	812	768	846	761	795	750	774	883	868	753	1581
1978	745	676	841	3581	6361	5805	2426	1319	1370	844	972	1149	10678
1979	1767	2711	2746	4571	9213	6919	2879	1680	1739	1635	1511	1412	15164
1980	1214	2580	1955	4225	9887	7174	2330	1305	1291	1007	1337	1518	13884
1981	1064	600	887	1337	1542	1393	1021	923	1181	1455	1083	823	3773
1982	1279	1388	1310	3463	6959	4748	2475	2077	2787	2731	2502	2443	9140
1983	1436	1360	1865	2839	8631	13662	7850	3138	2207	2477	2284	2582	20640
1984	2848	2630	2703	4968	13738	13722	6757	2894	2525	2998	2955	3180	20782
1985	2835	2360	2021	6747	10494	10121	3312	1567	2319	2723	2557	2655	15186
1986	2519	1744	3803	5796	8378	6447	5018	1995	2747	3378	3236	3305	10357
1987	2073	1885	2035	5198	6706	5877	2023	2088	2369	1851	1575	1569	9241
1988	1145	1301	1168	2309	2206	1901	1509	963	1351	1148	937	867	3436
1989	1027	1278	1790	2566	1805	1594	1442	1110	1258	1148	970	892	2465
1990	778	725	792	1007	1643	1662	1363	908	1156	1353	1163	1194	2574
1991	988	919	1042	1854	4985	4124	1937	1680	2073	1942	1702	1813	8412
1992	1135	956	1175	3314	3712	2731	2088	1702	1784	1961	1716	1396	6063
1993	1083	1325	2857	4991	12960	9242	3771	2220	2374	2650	2244	1969	20492
1994	1344	1230	1505	2167	3534	2830	1568	1251	1562	1771	1579	1518	4919
1995	1143	1056	2700	3797	8893	13680	12698	3043	2695	2780	2832	2762	19346
1996	1674	2286	2858	4046	5822	3341	1903	1541	2065	1956	1982	2079	7860
1997	2706	2739	2972	4431	8647	8757	3408	2517	3232	3188	2824	2730	11996
1998	1582	1469	2141	3646	7196	3200	2295	1545	1890	2049	1841	1732	9877
1999	1178	1159	1461	1383	3276	4499	2851	2882	2751	2468	2229	2188	6793
2000	1456	1464	1609	2764	2729	1831	1661	1141	1440	1623	1246	1133	4817
2001	1073	924	1176	1520	2939	2184	1817	1545	1841	1689	1403	1358	3487
2002	1069	911	904	1095	918	731	708	835	1097	1154	883	749	1153
2003	705	699	787	1169	2998	1809	629	767	1233	1020	859	753	5312
2004	754	730	1117	2039	2409	1543	1385	936	1325	1306	981	887	3413
2005	1206	1734	1578	4324	8022	4545	2184	1478	1686	1949	1528	1221	13574
Avg	1377	1408	1711	3122	5718	4993	2820	1641	1862	1895	1697	1650	

Development of water resources in the Gunnison Basin began in the late 19th Century, primarily for irrigation. Storage reservoirs were generally small and spring peak flows, while reduced, remained high. The extensive irrigation diversions significantly reduced summer and fall base flows and probably increased summer water temperatures and concentrations of pollutants.

Construction of storage reservoirs, including the Aspinall Unit, increased significantly in the second-half of the 20th century and greatly reduced spring peak flows while tending to increase base flows from early to mid-20th century levels (Figure 5 in Section 4.3). Tyus and Saunders (2001) concluded that the Aspinall Unit resulted in extreme alteration of historic flows in the Gunnison River.

The Aspinall Unit has not significantly changed the annual volume of water flowing downstream but has changed the flow pattern. The Aspinall Unit's operation has tended to increase flows from August through March or April and to reduce flows in May through July. Extreme low flows in the lower Gunnison have largely been eliminated. Prior to operation of the Aspinall Unit, average monthly flows at Whitewater were often below 900 cfs and occasionally below 200.

3.4.3 Water Quality

Butler (2000) summarized water quality data for the Gunnison River in critical habitat under baseline conditions. Three parameters were reported to exceed State water-quality standards (for which 85th percentile concentrations exceeded numeric standards) for the Gunnison River-sulfate, total iron, and selenium. Other constituents occasionally exceed standards but the 85th percentiles were less than the standards. Water released from the Aspinall Unit is of very high quality and tends to dilute inflows of pollutants from tributaries such as the North Fork and Uncompahgre rivers. Overall, operations of the Aspinall Unit have improved chemical water quality conditions in the critical habitat of endangered fish. Attachment 5 contains detailed water quality data collected by the U.S. Geological Survey at the Whitewater gage and in the Colorado River in critical habitat.

Of the elements that exceed state standards, selenium is of concern to fish and wildlife resources. Potential biological effects of selenium concentrations are discussed in Section 4.3. It is estimated that deep percolation and seepage of water from irrigation and irrigation systems contribute about 90 % of the groundwater that mobilizes selenium in the basin (Reclamation 2006). It is estimated that 60 % or more of the selenium loading measured at the Whitewater gage originates from an area encompassing the Uncompahgre River basin and the service area of the Uncompahgre Irrigation Project; the remainder from private water uses, other federal projects and natural inputs. Loading is highest from newly irrigated lands and gradually subsides. Selenium loading to the Gunnison River primarily results from canal/lateral seepage and deep percolation from irrigated fields, lawns, and ponds. Runoff from desert lands with Mancos shale derived soils is another source. The majority of the loading to the Gunnison River occurs on the east side of the Uncompahgre Valley and the majority of the loading to the Colorado River occurs in the Grand Valley. Hamilton (1999) reported that selenium concentrations in the early part of the 20th century were significantly higher in major rivers and tributaries than at present and hypothesized that these extreme concentrations may have played a significant role in the decline of the fish. Concentrations in the Gunnison River as high as 80 ppb were reported during this period (NIWQP display based on Hamilton 1999).

Attachment 6 includes graphs of dissolved selenium concentrations from 132 samples taken at various flows between 1976 and 1998 at the Whitewater Gage. The graph shows a general inverse correlation between flow rate and selenium concentration. However, the corresponding selenium concentration varied widely at flows under 4,000 cfs. For instance, the maximum recorded selenium concentrations corresponding to flows greater than 4,000 cfs was 3 ppb while at flows between 2,000 and 3,000 cfs concentrations varied from 1 to 10 ppb. The median value for these samples was 5 ppb; the Colorado chronic water quality standard for selenium is 4.6 ppb. Attachment 6 also contains tables of average monthly, average annual, maximum annual and minimum annual selenium concentrations through the study period for baseline and the proposed action.

Concentrations of selenium in the lower Gunnison River and elsewhere in the Colorado River Basin may be a concern for endangered fish. During informal consultation, the Service has requested that selenium issues be addressed in this PBA.

Beginning in the late 1980's, Reclamation, the Service, the U.S. Geological Survey and others participated in the National Irrigation Water Quality Program (NIWQP) to identify selenium sources and problems and to implement solutions. The NIWQP determined that "Selenium concentrations in the lower Gunnison River are at levels that adversely affect reproduction in selenium sensitive species including some aquatic birds and endangered fish." The Service (1994) recommended *in situ* studies to help determine whether trace elements such as selenium are limiting razorback survival in the Gunnison. Concerns were also noted in certain backwaters of the Green and mainstem Colorado River and in the Colorado downstream from the Gunnison confluence. Further, in a December 1998 memo, Region 6 of the Service stated the "The Service believes that the remediation of selenium impacts is one of several factors that needs to be addressed as part of the overall effort to recover the Colorado River endangered fishes."

In August 2002 the Service published Recovery Goals for the razorback sucker and Colorado pikeminnow which include:

> "Selenium is hypothesized as contributing to the decline of the endangered fishes of the Colorado River Basin (U.S. Fish and Wildlife memorandum, December 22, 1998). It is a water quality factor that may inhibit recovery by adversely affecting reproduction and recruitment (Stephens et al. 1992; Hamilton and Waddell 1994; Hamilton et al. 1996; Stephens and Waddell 1998; Osmundson et al. 2000a). Selenium concentrations in certain areas of the basin (e.g., Green River near Jensen, Utah; Gunnison River downstream from the Uncompahgre River confluence; and upper Colorado River downstream from Palisade, Colorado) exceed those shown to impact fish and wildlife elsewhere, and, although results are inconclusive as to exposure thresholds that cause specific effects, some studies suggest deleterious effects on razorback

> sucker and Colorado pikeminnow. The National Irrigation Water Quality Program is addressing selenium issues in the upper basin by implementing remediation projects to reduce selenium levels in areas of critical habitat. The adverse effects of selenium contamination on razorback sucker reproduction and survival will be reevaluated before downlisting and necessary protection will be implemented before delisting."

In 1998, the NIWQP began actions to mitigate selenium impacts both in the lower Gunnison River basin and in the Grand Valley in the vicinity of Grand Junction. However, funding for the NIWQP was suspended in 2004.

In 1997, the Colorado Water Quality Control Commission (Commission) lowered the state selenium standard for aquatic life to 4.6 ppb in the lower Gunnison River to be consistent with the EPA national standards. The Commission also requested that a group of local, state, and federal agencies organize and work to specifically reduce selenium loading.

As a result, the Gunnison Basin Selenium Task Force (Task Force) was formed in 1998 to address exceedance of the State's water quality standard for selenium in four stream segments including the lower Gunnison River. The Task Force is "a group of private, local, state and Federal interests committed to finding ways to reduce selenium in the affected reaches while maintaining the economic viability and lifestyle of the lower Gunnison River basin." Task Force members include City of Delta, City of Montrose, Colorado Department of Health and Environment, Colorado Division of Water Resources, Colorado Division of Wildlife, Colorado River Water Conservation District, Colorado Soil Conservation Board, Colorado State University Cooperative Extension, commercial farmers, ranchers, and dairymen, Delta County Commissioners, Delta County Health Department, Delta Soil Conservation District, High Country Citizens Alliance / Sierra Club, Montrose County Commissioners, Natural Resources Conservation Service, Shavano Soil Conservation District, Towns of Hotchkiss and Paonia, Uncompahgre Valley Water Users Association, Reclamation, the Service, the U.S. Geological Survey and others. The Task Force staff has recently been funded by the Colorado River Water Conservation District and Reclamation. Additional funding in earlier years was acquired through grant programs.

In addition to specific selenium reduction activities, extensive salinity-control activities have been underway in the lower Gunnison River basin as well as along the mainstem Colorado in the Grand Valley and in the Green River basin. These activities also contribute to the reduction of selenium loading.

Significant salinity control efforts began first in the Grand Valley where 246 miles of canals and laterals have been lined or placed in pipe and 34,565 acres have been treated with on-farm measures. Although targeted at salinity reduction, these projects also reduce selenium loading. In addition, backwater areas at the Orchard Mesa and Colorado River Wildlife Areas have been treated under NIWQP to reduce selenium concentrations in areas used by endangered fish and these efforts have been partially successful.

The first improvements in the Lower Gunnison area occurred under the Natural Resources Conservation Service's salinity control programs and later under the EQIP. Work generally involved on-farm irrigation efficiency improvements aimed at reducing deep percolation and salt loading. The EQIP remains active in the lower Gunnison basin. The major practices being installed are underground pipelines, ditch lining, land leveling, irrigation water control structures, sprinkler systems, gated pipe, and surge irrigation systems**.** Approximately $54 million has been expended to reduce salinity loading by 88,000 tons per year through fiscal year 2007. Unquantified reductions in selenium loading have also very likely occurred due to this work.

During the early 1990's, Reclamation implemented a project to replace the use of Uncompahgre Project canals and laterals carrying winter livestock water with a system of piped domestic water delivery facilities; and this reduced seepage throughout the Uncompahgre Valley. This program had a total cost of $24 million and reduced the loading of an estimated 41,000 tons of salt annually and an unquantified amount of selenium.

Beginning in 1998, targeted selenium control projects in the lower Gunnison River Basin have been developed through the efforts of the Reclamation-funded NIWQP, the Gunnison River Basin Selenium Task Force, and Uncompahgre Valley Water Users Association (UVWUA). Successful applications have been awarded project funding by the CRBSCP. This funding has been supplemented by NIWQP funding and in-kind services from the UVWUA. An initial lateral piping project was constructed south of Montrose in the Montrose Arroyo drainage (Phase I, East Side Laterals Project). The USGS reported significant selenium and salinity load reductions as a result of this project. Based on the success of that project, additional projects (Phases 2 and 3) have been funded by the CRBSCP, supplemented by Congressional "write-ins" for selenium control and continued in-kind services from UVWUA. These projects involve the piping of unlined irrigation laterals on the east side of the Uncompahgre Valley, the highest selenium loading area in the lower Gunnison River Basin. Approximately 51 miles of irrigation laterals on the east side of the Uncompahgre Valley have been placed in pipe, or are presently funded for piping, to reduce salt and selenium loading. This effort is summarized in Table 9.

Figure 2 indicates a general reduction in selenium concentrations in recent years, probably as a result of activities discussed above. The increase in concentrations in the 2002-2004 period results from the extreme drought and low water conditions in that timeframe.

Table 9. Status of East Side Uncompahgre Valley Laterals Project***.**

Phase	Original length of piped laterals (miles)	Salt reduction (tons/yr)	Salinity Program Funding ($)	Selenium Funding ($)	Total Funding[(1)] ($)
1	8.5	2,300	695,366	550,809	1,246,175
2	20.5	6,100	2,133,000		2,133,000
				1,706,000	1,706,000
3	10.5	2,300	1,262,561		1,262,561
4	11.4	3,651	2,002,285	800,000	2,802,285
total	50.9	14,351	$6,093,212	$3,056,809	$9,150,021

*Total Funding does not include resources and in-kind services contributed by the Uncompahgre Valley Water Users Association.

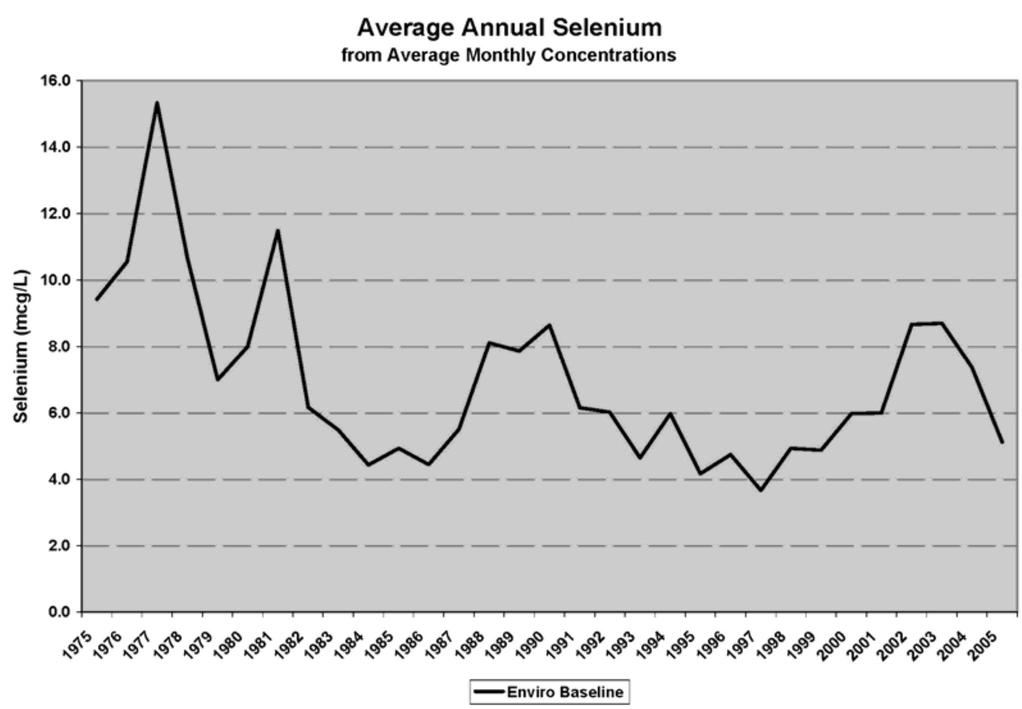


Fig 2. Baseline average annual selenium concentrations, Gunnison River at Whitewater gage.

In 2006, Reclamation in conjunction with the Task Force produced an appraisal-level report evaluating selenium remediation concepts for the lower Gunnison River Basin (Bureau of Reclamation 2006a). The purpose of the report was to determine the reasonableness of attaining certain water quality goals. The report identified two remediation alternatives.

Alternative 1: Water Quality Standard Attainment Plan to meet State water quality standard
Alternative 2: Endangered Species Protection Plan to meet the NIWQP goal for food organisms

Based on 1997-2001 streamflow levels, the following selenium reduction amounts were estimated for these two alternatives:

Alternative 1: Meet selenium water quality standards (85th percentile value of 4.6 ppb)

Meet standard at:	Load reduction needed
Uncompahgre River at Delta	5,630 pounds/year
Gunnison River at Whitewater	5,000 pounds/year

Notes: 1) these values are not additive; if 5,630 lbs/year is reduced in the Uncompahgre, the standard is met at Whitewater; 2) the period of record for this computation was 1997-2001; using a different period will likely change the required load reduction.

Alternative 2: Meet the NIWQP goal of 3 ppm in food organisms

Meet goal at:	Load reduction needed
Gunnison River at Whitewater	~ 13,000 pounds/year

Notes: 1) The 5-year average selenium load is about 7,600 pounds/year for the Uncompahgre River at Delta and 19,400 lbs. /year for Gunnison River at Whitewater.

The projected load reductions needed to meet the State Standard (Alternative 1) were based on detailed USGS studies and have a reasonable level of certainty. In the case of Alternative 2, the estimate of selenium reduction needed to meet 3 parts per million (ppm) is of much lower certainty, being based only on rough approximations developed by the NIWQP. Reclamation considers the selenium load reduction needed to meet the 3 ppm goal in food organisms to be unknown.

The 2006 report suggested that Alternative 1 - meeting the state water quality standard for selenium in the lower Gunnison and Uncompahgre Rivers - was technically attainable based on the selenium reduction needed for the 1997 to 2001 period of record. Alternative 1 includes piping 127 miles of laterals and lining 19 miles of canals on the east side of the Uncompahgre Valley along with significant on-farm and other improvements. Based on the 2006 report, it was projected that if all these improvements are implemented, selenium loads would be reduced by 4,300 to 6,100 pounds/year.

The quantification of the selenium reduction needed to meet the state standard in the lower Gunnison River is dependent on the hydrologic period of record selected. A 2008 study completed by the USGS (for use in developing the State's TMDL) uses a 2001-2005 period and documents the need to reduce the load by about 8,600 pounds per year to achieve the standard during that time period.

The availability of funding is the primary limiting factor in implementing selenium and salinity reduction plans. Additionally, the continuing implementation of beneficial salinity control projects is dependent on the competitive selection of such projects by the CRBSCP and supplementary funding provided via Congressional “write-ins” garnered by the UVWUA and others. The continuation of both the CRBSCP and EQIP are dependent on Congressional funding.

It should also be noted that urban/suburban growth and land-use changes are believed to significantly affect both selenium and salt loading in the area. Some trends appear to be downward, but growth that occurs on lands that were not previously irrigated (and leached) and new aesthetic or recreational ponds may be countering the trends. Studies are currently underway by the US Geological Survey to evaluate land use changes and effects on salinity and selenium loading. These studies are being funded through the CRBSCP.

Another water quality consideration, water temperature, can affect the life cycles of the fish. Early irrigation diversions and return flows probably tended to increase water temperatures in the Gunnison River and its major tributaries year-round. Later construction and operation of the Aspinall Unit has tended to lower downstream temperatures in the summer and raise them in the winter, due to hypolimnion releases from the reservoirs. Stanford and Ward (1983) reported that the river immediately downstream from the Aspinall Unit was several degrees warmer in the winter and 7-10 degrees C cooler in the summer. Before reservoir regulation, annual degree days increased from 2,895 to 4,132 between the East Portal and Whitewater; and after regulation increased from 1,361 to 3,432.

Table 10 presents recent temperature data from the Gunnison River collected under the Recovery Program. There is a general inverse correlation between flow and water temperature at Delta and Whitewater with higher releases resulting in lower water temperatures (for example, see 1993, 1995, and 1997 in Table 10), although this is not always true as other variables such as tributary flow and weather affect the temperatures also. Additional water temperature data and the relationship between temperatures at Crystal Dam and the Whitewater gage are found in Attachment 6. Spring and summer water temperatures in areas such as backwaters would be expected to be higher than in main channel areas.

3.4.4 Climate Change

In determining what future effects are reasonably certain to occur, Reclamation must determine the difference between future effects that are speculative, and effects that are likely to occur under the environmental baseline as compared to the proposed actions. The hydrologic and water quality models included variability designed to reflect conditions likely to occur over the 25 year time frame for this consultation. However, future climatic conditions could be warmer, wetter, cooler, or drier than the modeled conditions.

Table 10. Mean summer water temperature (degrees C) of the Gunnison River at the Delta and Whitewater gages, 1992-2000 (from McAda 2003).*

Year/Month/Mean Flow at Whitewater+	Gunnison River at Delta	Gunnison River at Whitewater	Year/Month/Mean Flow at Whitewater+	Gunnison River at Delta	Gunnison River at Whitewater
1992			1997		
Jun 2,819 cfs	16.1	17.9	Jun 8,184 cfs	13.2	12.6
Jul 1,806 cfs	17.6	20.3	Jul 3,595 cfs	16.2	18.1
Aug 1,716 cfs	17.5	20.6	Aug 2,474 cfs	17.7	19.7
Sep 1,570 cfs	15.4	17.9	Sep 3,257 cfs	15.8	17.1
1993			1998		
Jun 9,054 cfs		13.2	Jun 3,273 cfs	14.3	16.2
Jul 3,279 cfs		18.1	Jul 1,913 cfs	19.0	21.7
Aug 2,157 cfs		19.3	Aug 1,472 cfs	18.0	
Sep 2,377 cfs		16.1	Sep 1,879 cfs	15.7	
1994			1999		
Jun 2,567 cfs		19.0	Jun 3,549 cfs	15.0	
Jul 1,263 cfs		21.7	Jul 2,423 cfs	18.4	
Aug 1,276 cfs		21.8	Aug 3,418 cfs	16.5	
Sep 1,701 cfs		17.1	Sep 3,172 cfs	14.6	
1995			2000		
Jun 13,050 cfs	11.4	12.0	Jun 1,941 cfs	16.5	19.5
Jul 11,950 cfs	13.5	13.7	Jul 1,520 cfs	18.6	21.6
Aug 3,162 cfs	17.7	19.5	Aug 1,792 cfs	18.1	20.8
Sep 2,399 cfs	15.5	17.0	Sep 1,799 cfs	15.7	17.0
1996					
Jun 4,034 cfs	14.8				
Jul 2,283 cfs	17.7				
Aug 1,391 cfs	18.6				
Sep 2,022 cfs	15.0				

*Data were compiled from thermographs maintained by the Recovery Program
+Monthly mean flow at U.S.G.S. gage at Whitewater

There is some general consensus among the scientific community that the West will experience warmer temperatures, longer growing seasons, earlier runoff of snowmelt, and more precipitation occurring as rain rather than snow. Specific predictions for the Gunnison Basin are highly speculative; however, predictions for the overall Colorado River Basin natural flows have ranged between reductions of 6 to 45 percent over the next 50 years (Reclamation 2007). Recent reports (Ray et al 2008) suggest continued warming in Colorado with less clear trends in annual precipitation, although in general lower and earlier runoff is predicted.

In the long-term, the timing and quantity of runoff into the Aspinall Unit may be affected and may affect expected results from the baseline or implementation of the proposed action either in a positive or negative manner. It is possible that the frequency of dry and moderately dry type years will increase, thus reducing the ability of the rivers to move sediment and maintain or improve habitat conditions. Conversely the magnitude of runoff events could become more variable and extreme and still provide conditions for sediment movement.

The hydrology modeling for this assessment does not project future inflows, but rather relies on the historic record to analyze a range of inflows. As discussed elsewhere in this assessment, the inflow to the Aspinall Unit has historically been highly variable and operations under the proposed alternative are planned to address this variability. The study period used in this analysis includes drought periods and both extremely dry and extremely wet years. Because the action being considered does not involve new construction of storage facilities or outlet features, sizing of facilities in relation to future climate is not a consideration. In addition, neither the baseline nor the proposed action itself are viewed as having any effect on climate.

The proposed alternative also includes an adaptive management process, supported by Recovery Program monitoring, to address new information about the subject endangered fish, their habitat, reservoir operations, and river flows. Reclamation will also continue to support multi-faceted research on climate change (Reclamation 2007). If climate results in effects to the listed species or critical habitats that were not considered in this PBA, then Reclamation would reconsult.

3.4.5 Water Rights

Gunnison River Basin water use began in the 19th century with the establishment of numerous irrigation water rights by individuals, organizations, and government agencies. There are more than 5,000 water rights for direct flow diversions presently in use on the river and its tributaries for irrigation, recreation, and municipal and industrial uses. There are an estimated 264,000 acres of irrigated land in the Basin (Colorado Department of Natural Resources 2006). Significant senior diversion rights established prior to 1910 include the Gunnison Tunnel of the Uncompahgre Project (1,300 cfs) located 2 miles downstream from Crystal Dam and the Redlands Diversion (750 cfs), located on the Lower Gunnison River 3 miles upstream from the Colorado River confluence. The 1933 Federal reserved right for the Black Canyon of the Gunnison National Park, also downstream, is currently being quantified and is predicted to be compatible with the proposed action under this PBA.

In addition to water rights for direct diversions and instream flows, there are significant storage and hydropower rights in place on the Gunnison River. The largest single perfected storage right is the 952,000 acre-foot decree for Blue Mesa Reservoir. There are also numerous small reservoirs and several larger Reclamation project reservoirs on tributaries with storage rights: Taylor Park Reservoir on the Taylor River, Silver Jack Reservoir on Cimarron Creek, Crawford Reservoir on the Smith Fork, Paonia Reservoir on the North Fork, Ridgway Reservoir on the Uncompahgre, and Fruitgrowers Reservoir on Alfalfa Run (see Attachment 1).

4.0 GUNNISON RIVER AQUATIC RESOURCES

Prior to water development in the Gunnison River, the upper river supported Colorado River cutthroat trout along with speckled dace, flannelmouth and bluehead suckers, and less common roundtail chubs and perhaps mottled sculpin (Wiltzius 1978); however, by

1900 native cutthroat had been largely replaced in the river and major tributaries by rainbow, brook, and brown trout due to stocking programs and habitat changes. Early in the twentieth century, the Gunnison already was considered a "world-renowned" trout fishery. The lower Gunnison River supported Colorado pikeminnow, razorback suckers, flannelmouth and bluehead suckers, roundtail chubs, speckled dace, sculpin, and perhaps humpback chub and bonytail. The razorback and perhaps the pikeminnow were common in the lower river as late as the 1950's (Burdick 1995).

The fishery of the Gunnison River and its major tributaries upstream from the Aspinall Unit are generally in good condition at the present time with rainbow, brown, and brook trout populations. Native cutthroat trout now occur only in isolated high elevation tributaries. Taylor Park Reservoir supports a rainbow and brown trout, lake trout, and northern pike fishery. The 1975 Taylor Park Exchange Agreement coordinates Taylor Park and Blue Mesa operations and has benefited fisheries of the Taylor and upper Gunnison rivers along with that of Taylor Park Reservoir itself. Fall migration runs of kokanee salmon from Blue Mesa to the Roaring Judy Hatchery on the East River support increasing recreational use.

Blue Mesa, Morrow Point, and Crystal Reservoirs are managed by the Colorado Division of Wildlife (CDOW) as sport fisheries. Public use and active management are limited at Crystal and Morrow Point due to the difficult access; however, the sport fishery at Blue Mesa is one of the largest and most valuable in Colorado. The present fish populations at Blue Mesa consists primarily of kokanee salmon, rainbow trout, lake trout, brown trout, longnose and white suckers, and longnose dace. Northern pike and more recently yellow perch have entered the fishery.

Downstream Morrow Point and Crystal Reservoirs are steep-sided oligotrophic reservoirs with limited access and fisheries. Survival of fish through the Blue Mesa powerplant provides limited "stocking" for Morrow Point and rainbow trout and kokanee are the most common species. Overall, escapement of non-native fish from the Aspinall Unit to the lower Gunnison River is not considered a significant problem because of mortality associated with the series of the three powerplants, depth of outlet works, and the infrequent spillway use at Blue Mesa and Morrow Point.

The Gunnison River from Crystal Dam to the North Fork Confluence has developed into a productive tailwater fishery due to relatively uniform and cold water releases and has been rated as a Gold Medal and Wild Trout (naturally reproducing) fishery by the CDOW. Bluehead suckers are common in this reach and flannelmouth are also present; and non-native longnose and white suckers and carp are found. Reservoir operations provide a minimum flow of at least 300 cfs through the Gunnison Gorge except in extreme droughts and emergencies and this has been beneficial to the fishery since the mid 1980's. Since the fishery is naturally reproducing, relatively stable daily flows during spawning and fry emergence and early development are critical.

Between the Gunnison River's North Fork Confluence and Austin, the river continues to support a quality trout fishery dominated by brown trout. In this reach roundtail chub, bluehead sucker, flannelmouth sucker, white sucker, and white sucker hybrids become more common. Between Austin and Delta, the trout fishery gradually declines due to warming summer water temperatures and increased turbidity.

Prior to any development, the lower river possibly supported eight fish species, including the bonytail, humpback chub, Colorado pikeminnow, and razorback sucker. By the 1990's, twenty-one species and three hybrids were reported in the lower 75 miles of the Gunnison downstream from the North Fork confluence (Burdick 1995), most with healthy reproducing populations. Seven of these species were native and three were endemic to the Colorado River Basin—the Colorado pikeminnow, humpback chub, and flannelmouth sucker. Other native fish in this reach were the bluehead sucker, speckled dace, roundtail chub, and mottled sculpin. Flannelmouth and bluehead suckers are the most common species.

The river downstream from the Uncompahgre confluence was designated as critical habitat in 1994 for the Colorado pikeminnow and razorback sucker. This reach of the Gunnison retains a healthy reproducing population of native fish and they comprised 79% of a total sample in 1993 surveys (Burdick 1995). This is an unusually high percentage of native fish for a river in the Upper Colorado River Basin and may result in part from the Redlands Diversion (RM 3) which served as a barrier to movement of non-native fish from the Colorado River for most of the 20th century. Numerically the most common fishes sampled were all native fish: bluehead sucker (36%), flannelmouth sucker (29%), and roundtail chub (14%). Kowalski (2008) reported on a more recent 2008 survey that continued to show a healthy population of native fish in the lower Gunnison River.

Floodplain habitat is important to the native fish, and the most extensive floodplain of the Gunnison River is in the 17-mile reach centered near Delta (between River Miles 50 and 67); and this reach has the most complex channel habitats with braided channels, islands, and backwaters (Burdick 1995). Prior to human settlement, the river upstream and downstream from Delta probably supported much more extensive floodplain habitat in this area. Downstream from River Mile 50, the river flows mostly through canyons with the limited floodplain areas developed for orchards, ranches, and gravel pits.

4.1 Discussion of Listed Species

The Service identified 9 endangered, 4 threatened, and 2 candidate species which could be affected by the proposed alternative (Fish and Wildlife Service 2008). Threatened or endangered species are formally listed under Section 7 of the ESA, while candidates are species for which the Service has sufficient information on their status and potential problems to propose them as endangered or threatened, but they have yet to be formally listed. Species of concern are species the Service believes to be vulnerable, but require further study to determine their status.

The species identified by the Service are as follows:

Vegetation

Clay-loving wild buckwheat	*Eriogonum pelinophilum*	endangered
Uinta Basin hookless cactus	*Sclerocactus glaucus*	threatened
Jones' cycladenia	*Cycladenia humilis var. jonesii*	threatened

Wildlife

Yellow-billed cuckoo	*Coccyzus americanus*	candidate
Mexican spotted owl	*Strix occidentalis lucida*	threatened
California condor	*Gymnogyps californianus*	endangered
Southwestern willow flycatcher	*Empidonax traillii extimus*	endangered
Black-footed ferret	*Mustela nigripes*	endangered
Canada lynx	*Lynx Canadensis*	threatened
Gunnison's prairie dog	*Cynomys gunnisoni*	candidate
Uncompahgre fritillary butterfly	*Boloria acrocnema*	endangered

Fish

Colorado pikeminnow	*Ptychocheilus lucius*	endangered
Razorback sucker	*Xyrauchen texanus*	endangered
Humpback chub	*Gila lacypha*	endangered
Bonytail	*Gila elegans*	endangered

Terrestrial wildlife and vegetation species are discussed in Section 5.0.

4.2 Endangered Fish

The Colorado River Basin originally supported a fish fauna with 36 species from 20 genera and 9 families. Of these 36 native species, 64 % were endemic to the basin and only eight were found in both upper and lower portions of the basin. The native fish of the major rivers in the Basin are long-lived and have evolved to live in a system of high spring snowmelt flows, periodic high turbidity, and a wide range of flows.

This PBA addresses the habitat and populations of endangered fish in the Gunnison River and to a lesser extent addresses these fish in the Colorado River downstream from the Gunnison confluence. Recovery Program activities for the Gunnison and Colorado rivers are also discussed. This assessment assumes that improvement in flow regimes in the Gunnison can have positive cumulative impacts on habitat in the Colorado River downstream from the Gunnison confluence. Recovery Program activities for the Gunnison River are discussed; however, it should be noted that there are also many activities under the Recovery Program involving the Colorado mainstem and other tributaries including activities to improve flow conditions, address non-native species, and conduct monitoring and research.

Historical information on the Gunnison River's fish populations is limited and was summarized by Burdick (1995):

> Jordan (1891) collected both Colorado squawfish and razorback sucker from the Gunnison and Uncompahgre Rivers near Delta. He also reported collecting one "bonytail"; however this specimen may have been confused with the more numerous roundtail chub, since they were considered

subspecies until 1970 (Holden and Stalnaker 1975). Chamberlain (1946) reported razorback sucker as common in the Gunnison River downstream from Delta, and also reported Colorado squawfish from the lower Gunnison River. Kidd (1977) reported that a commercial fisherman frequently collected both Colorado squawfish and razorback sucker from 1930 until 1950 near Delta. Some razorback sucker were collected by CDOW during the 1950’s, and one was collected near Delta in 1975 (Wiltzius 1978). Anecdotal accounts also suggest razorback sucker may have been abundant in the Delta area. Quartarone (1993) cites local Delta residents reporting both Colorado squawfish and razorback sucker as common in the Delta area and that razorback sucker used to enter the Hartland Diversion Ditch where they became stranded. Kenneth and Wendell Johnson (Personal communication 1993), long-time residents of Delta, indicated that they commonly caught razorback sucker in homemade traps in a flooded oxbow that was connected to the Gunnison River during spring runoff. They also added that they noticed that razorback sucker numbers declined rapidly in the late 1950’s. Wiltzius (1978) believed that the Redlands Diversion reduced Colorado squawfish numbers in the Gunnison River by preventing upstream movement from the Colorado River.

4.2.1 Colorado pikeminnow (*Ptychocheilus lucius*)

4.2.1.1 General

The Colorado pikeminnow is the largest member of the minnow family in North America and historically was the top predator fish species in the Colorado River system. This long-lived fish was found throughout warm water reaches of the entire Colorado River Basin downstream to the Gulf of California. Loss of approximately 75 % of its historic range, unknown status in the Upper Basin and threats of further habitat loss prompted listing of Colorado pikeminnow as an endangered species in 1967. Critical habitat was designated on March 21, 1994 (59 FR 13374) as six reaches (1,848 km) of the Upper Colorado River Basin or about 29% of historic habitat, including portions of the Upper Colorado, Green, Yampa, White and San Juan rivers.

Today, Colorado pikeminnow occur in the Green River from Lodore Canyon to the confluence of the Colorado River (Tyus 1991; Bestgen and Crist 2000); the Yampa River downstream of Craig, Colorado (Tyus and Haines 1991); the Little Snake River from its confluence with the Yampa River upstream into Wyoming (Marsh et al. 1991; Wick et al. 1991); the White River downstream of Taylor Draw Dam and Kenney Reservoir (Tyus and Haines 1991); the lower 143 km of the Price River (Cavalli 1999); the lower Duchesne River; the upper Colorado River from Palisade, Colorado, to Lake Powell (Valdez et al. 1982b; Osmundson et al. 1997, 1998); the lower 54 km of the Gunnison River (Valdez et al. 1982a; Burdick 1995); and the lower 2 km of the Dolores River (Valdez et al. 1982a). The Green River and its major tributaries support the largest population of Colorado pikeminnow (2,142 adult fish; Bestgen et al. 2007). The upper

Colorado River adult population increased from 372 in 1991-1994 to 534 fish during 1998-2000 (Recovery Program 2006b).

4.2.1.2 Distribution and Abundance in the action area

While data is scarce, it does appear that the Gunnison historically supported a population of pikeminnow that at some point in time declined markedly. Wiltzius (1978) summarized written and anecdotal reports on this species; information on the relative abundance of the species was not consistent within these reports. Surveys since 1980 revealed only a very small remnant population in the Gunnison River (Valdez et al. 1982a; and Wick et al. 1985).

More recently, Burdick (1995) captured 5 adult pikeminnow during the 1992-1994 period. All fish reported by Burdick (1995) and Valdez et al. (1982a) were captured between RM 17 and 48, with most occurring near RM 33. During 2006 sampling, 2 wild adult pikeminnow were captured (McAda and Burdick 2006), although none were collected during 2007 (McAda and Burdick 2007). Figure 3 presents recent distribution information.

Larval Colorado pikeminnow were collected in very small numbers downstream from the Redlands Diversion in 1992, 1995, and 1996 and larval fish were collected near RM 29 and RM 5.5 in the mid-1990s (Osmundson and Kaeding 1989; Anderson 1994; Burdick 1995; and Anderson 1999). A possible spawning area was located between RM 32 and 33 based on congregation of radio-tagged fish and collection of larvae downstream. In 2006, a pikeminnow originally tagged in 1993, was captured at RM 32.3 in July.

Although pikeminnow use the entire Colorado River above Lake Powell, there are distinct differences in distribution among age classes. In general, most adults are found in the upper reaches of the Colorado River and most sub-adults, juveniles, and young-of-year (YOY) are found in the lower reaches (McAda 2003; Valdez et al. 1982b; Archer et al. 1985; McAda and Kaeding 1991; Osmundson et al. 1997). This difference in distribution may relate to increased abundance of appropriate-sized prey in upstream reaches (Osmundson 1999). Studies involving catch-rates indicate that the Gunnison River has a relatively high population of fish that could serve as potential prey for pikeminnow (Osmundson 1999).

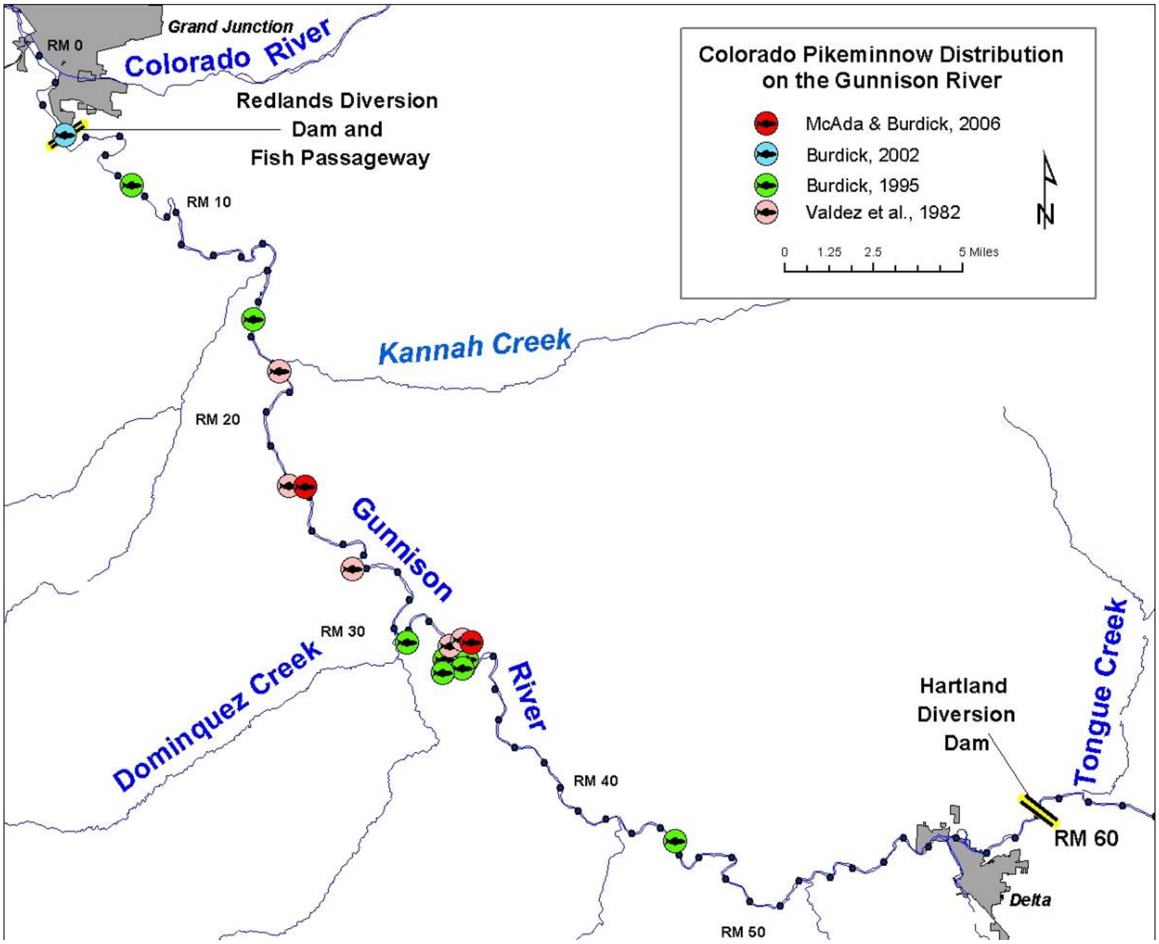


Figure 3. Recent distribution, Colorado pikeminnow, Gunnison River.

4.2.1.3 Life history

Colorado pikeminnow in the upper Colorado River sub basin live to at least 12 years (Hawkins 1992). Larvae at hatching are 6.0–7.5 mm long and grow under laboratory conditions at about 13 mm/month (Hamman 1981). Mean annual growth rate of fish from the upper Colorado River aged 3–6 years ranged from 32.2 (age 6) to 82.0 (age 3) mm/year and declined to 19.8 mm/year for fish 500–549 mm total length (TL) (Osmundson et al. 1997); fish 550 mm and larger grew an average of 9.5 mm/year. Average-sized Colorado pikeminnow in the upper basin are 450–550 mm TL and weigh 1–2 kg.

The Colorado pikeminnow is an obligate warm-water species that requires relatively warm temperatures for spawning, egg incubation, and survival of young. Hatchery-reared males became sexually mature at 4 years of age and females at 5 years. Spawning activity begins after the peak of spring runoff during June-August at water temperatures typically 16°C or higher (Vanicek and Kramer 1969; Hamman 1981; McAda 2003; Muth et al. 2000). Spawning in the Gunnison River, based on limited larvae collection, ranged from early June to mid-July. Colorado pikeminnow are broadcast spawners that scatter adhesive eggs over cobble substrate which incubate in interstitial spaces. Hatching success is greatest at 20–24°C with incubation time of 90–121 hours (Hamman 1981; Marsh 1985).

Survival and recruitment of Colorado pikeminnow is pulsed, as a strong year class appears and is reflected in the size composition of the population over time. This "storage effect" (Gilpin 1993) enables long-lived populations to maintain themselves despite several years of failed or low reproductive success. Greatest cohort strength in the upper Colorado River (i.e., 1986, 1996) occurred 1–2 years after high river flows, indicating that high velocities are needed to flush excessive sediments and organics from interstices of spawning cobbles, which otherwise suffocate eggs and reduce survival of larvae. McAda and Ryel (1999) noted that especially strong cohort strength in the Colorado River was related to high spring peak flows (ca. 50,000 cfs) during the previous year and moderately high spring peaks (30,000 to 40,000 cfs) during the year in which the fish were produced. Successful cohorts during high flows may be precluded by delayed warming of the river which causes delayed spawning, poor age-0 survival, and/or displacement of larvae beyond optimal rearing habitat (Thompson et al. 1991; Converse et al. 1998), but these high peaks may be necessary to provide optimal spawning conditions during the following year.

Studies of overwinter survival show a significant relationship between densities of age-0 fish in fall and spring, suggesting that high spawning success and egg and larval survival by fall (i.e., 3–4 months of age) largely determine cohort strength (Valdez et al. 1999; McAda and Ryel 1999). Overwinter survival also influences cohort strength, but the linkage to environmental correlates (e.g., flow variability, river temperature and ice formation, average backwater depth, and non-native fish density) is unclear. Overwinter survival was related to backwater depth with higher survival (85%) in backwaters deeper than 120 cm and lowest survival (18%) in backwaters less than 30 cm deep (Valdez et al. 1999). In the upper Colorado River, overwinter survival ranges from 7–77% (mean, 49%; McAda and Ryel 1999). Survival rates of adults >550 mm TL from the upper Colorado River is about 85% (Osmundson et al. 1997).

Backwaters and other low-velocity shoreline habitats in alluvial reaches of the upper Colorado, Green, and San Juan rivers are important nursery areas for larval and juvenile Colorado pikeminnow (Tyus 1991; Holden 2000; McAda 2003; Muth et al. 2000), and researchers believe that non-native fish species in those habitats limit the success of Colorado pikeminnow recruitment (e.g., Muth and Nesler 1993; Bestgen et al. 1997; McAda and Ryel 1999; Valdez et al. 1999). Non-native fish assemblages in these habitats are dominated by fathead minnow, sand shiner and red shiner. McAda and Ryel (1999) demonstrated that abundance of these non-native species during both summer (larvae) and autumn (juvenile and adults) was inversely correlated with magnitude of the previous spring peak flows, whereas relationship of young-of-year native fish to spring peak flows was either positive or statistically not significant.

Young Colorado pikeminnow remain near nursery areas for the first 2–4 years of life, and then move upstream to recruit to adult populations and establish home ranges

(Osmundson et al. 1998). Adult Colorado pikeminnow remain in home ranges during fall, winter, and spring and may move considerable (up to 950 km) distances to and from spawning areas in summer (Irving and Modde 2000) . Individuals move to spawning areas shortly after runoff in early summer, and return to home ranges in August and September (Tyus 1990; Irving and Modde 2000). Long range movement of Colorado pikeminnow among the Green and Colorado rivers suggests that the upper basin population is panmictic with evidence of source/sink dynamics (Gilpin 1993).

4.2.1.4 Colorado Pikeminnow Habitat

Colorado pikeminnow live in warm-water reaches of the Colorado River mainstem and larger tributaries, and require uninterrupted stream passage for spawning migrations and dispersal of young. Throughout most of the year, juvenile, subadult, and adult Colorado pikeminnow utilize relatively deep, low-velocity eddies, pools, and runs that occur in nearshore areas of main river channels (Tyus and McAda 1984; Valdez and Masslich 1989; Tyus 1990, 1991; Osmundson et al. 1995). In spring, however, Colorado pikeminnow adults utilize floodplain habitats, flooded tributary mouths, flooded side canyons, and eddies that are available only during high flows (Tyus 1990, 1991; Osmundson et al. 1995). Such environments may be particularly beneficial for Colorado pikeminnow because other riverine fishes gather in floodplain habitats to exploit food and temperature resources, and may serve as prey. Such low-velocity environments also may serve as resting areas for Colorado pikeminnow. River reaches of high habitat complexity appear to be preferred.

During most of the year, distribution patterns of adults are stable (Tyus 1990, 1991; Irving and Modde 2000), but distribution of adults changes in late spring and early summer, when most mature fish migrate to spawning areas (Tyus and McAda 1984; Tyus 1985, 1990, 1991; Irving and Modde 2000). High spring flows provide an important cue to prepare adults for migration and also ensure that conditions at spawning areas are suitable for reproduction once adults arrive. Specifically, bankfull or much larger floods mobilize coarse sediment to build or reshape cobble bars, and they create side channels that Colorado pikeminnow sometimes use for spawning (Harvey et al. 1993). Spawning occurs in gravel-cobble substrates in riffles and runs, and adjacent pools or backwaters can be used for resting or staging. Spawning habitat in the action area is located in meandering, alluvial reaches susceptible to considerable change during years of high flows (McAda 2003). Thus, while spawning doesn't necessarily occur in the same area from one year to the next, six sites in the action area have been identified as potentially important areas for spawning activity:

1) The Colorado River reach immediately above the Gunnison River confluence
2) Two Colorado River reaches below the Gunnison river and above Westwater Canyon
3) The Colorado River downstream from Westwater Canyon near Fish Ford
4) The Gunnison River immediately below Redlands Diversion
5) The Gunnison River near RM 32

Cobble-gravel bar complexes that typify these sites are found at many locations in the upper Colorado River basin, however, and spawning activity can vary spatially from one year to the next.

Eggs are broadcast on cobble substrates in riffles and runs and incubate in the interstitial spaces for 4-7 days before hatching. The new larvae remain in the gravel/cobbles for about one week and then emerge and enter the river current. After emerging, Colorado pikeminnow larvae drift downstream to backwaters in sandy, alluvial regions, where they remain through most of their first year of life (Holden 1977; Tyus and Haines 1991; Muth and Snyder 1995). Backwaters and the physical factors that create them are vital to successful recruitment of early life stages of Colorado pikeminnow, and age-0 Colorado pikeminnow in backwaters have received much research attention (e.g., Tyus and Karp 1989; Haines and Tyus 1990; Tyus 1991; Tyus and Haines 1991; Bestgen et al. 1997). It is important to note that these backwaters are formed after cessation of spring runoff within the active channel and are not floodplain features. Colorado pikeminnow larvae occupy these in-channel backwaters soon after hatching. They tend to occur in backwaters that are large, warm, deep (average, about 0.3 m in the Green River), and turbid (Tyus and Haines 1991). Recent research (Day et al. 1999, 2000; Trammell and Chart 1999a, 1999b) has confirmed these preferences and suggested that a particular type of backwater is preferred by Colorado pikeminnow larvae and juveniles. Such backwaters are created when a secondary channel is cut off at the upper end, but remains connected to the river at the downstream end. These chute channels are deep and may persist even when discharge levels change dramatically. An optimal river-reach environment for growth and survival of early life stages of Colorado pikeminnow has warm, relatively stable backwaters, warm river channels, and abundant food (Muth et al. 2000).

Summer water temperatures at Whitewater only infrequently exceed optimal ranges for Colorado pikeminnow growth, and upstream reaches appear to be too cool for pikeminnow reproduction (see Table 10 and Attachment 6). Due to cool releases from the Aspinall Unit, Gunnison River summer temperatures in critical habitat were about 3 degrees °C cooler than river reaches in other parts of the Colorado River Basin that have relatively large populations of endangered fish. Osmundson (1999) considered the potential for extending the range of endangered fish in the Gunnison River, and determined that distribution of Colorado pikeminnow was temperature-limited and extended only to about 33 miles upstream of the Colorado River confluence (Dominguez Creek – Peeples Orchard). Cooler water upstream does not preclude fish from using upper reaches but the cooler temperatures can interfere with life processes such as reproduction and can lower growth rates. Osmundson (1999) reported good prey and habitat conditions upstream, but only sporadic use by Colorado pikeminnow and hypothesized that water temperature may reduce the upstream use.

4.2.1.5 Flow and habitat maintenance

The relationship between flow regimes and habitat maintenance was summarized in McAda (2003):

Spring
- Increasing flows cue fish to prepare for migration and spawning
- High flows inundate floodplain habitats to provide warm food-rich environments for growth and gonadal maturation
- High flows scour vegetation on banks and side channels to maintain habitat complexity
- High flows scour sediment from the cobbles and gravels to provide suitable location for eggs and larvae
- High flows mobilize the bed in runs and riffles; fines are flushed from the substrate and interstitial spaces
- High flows transport sediment and build in channel bars for backwater habitat
- High flows reduce non-native predators and competitors

Late Spring/Early Summer
- Declining flows and increasing water temperatures initiate migration and spawning
- Flows are sufficient to provide migration routes
- Flows are sufficient to prevent sedimentation of eggs and larvae

Summer
- Base flows maximize preferred habitat and sufficient depth for movement
- Base flows maximize backwater habitats available to young fish

Winter
- Base flows maximize preferred habitat and sufficient depth for movement and resting
- Base flows maximize backwater habitats available to young fish

4.2.2 Razorback sucker (*Xyrauchen texanus*)

4.2.2.1 General

The razorback sucker is a large catostomid and is endemic to the Colorado River. It is a long-lived fish and historically was found throughout warm water reaches of the entire Colorado River Basin downstream to the Gulf of California. By the 1990's, the largest riverine population was found in the middle Green River. The razorback sucker was listed as endangered under the ESA on October 23, 1991 (56 FR 54957). Critical habitat was designated on March 21, 1994 (59 FR 13374) as 15 reaches (2,776 km) of the Colorado River System or about 49% of historic habitat, including portions of the Colorado, Green, Yampa, Duchesne, White, Gunnison, and San Juan rivers in the upper basin, and portions of the Colorado, Gila, Salt, and Verde rivers in the lower basin. A recovery plan was approved in 1998 and amended and supplemented with recovery goals in 2002 (U.S. Fish and Wildlife Service 2002d).

4.2.2.2 Distribution and abundance in the action area

It appears that razorback sucker was once abundant in the Gunnison River, yet significantly declined in the second-half of the 20th century, perhaps becoming totally expatriated from the river by the 1990's. Historical information on the Gunnison River's fish populations is limited and was summarized by Burdick (1995) (Section 4.2).

Prior to Recovery Program activities, the last wild adults were captured near Delta in 1981 (Holden et al. 1981). Extensive sampling after that failed to capture any more individuals of the species in the Gunnison (McAda 2003). Since 1994, over 50,000 razorback sucker (ranging from 100 to 300 mm in length) have been stocked in the Upper Colorado River Basin (Burdick 2003). Most stocking occurs in the Colorado River, although approximately 3,000 razorback suckers per year are currently stocked in the Gunnison River (Tom Czapla, personal communication; Burdick 2003). Fish stocked at a minimum of 200 mm total length are recaptured most frequently. Stocked razorbacks are surviving in the Gunnison River and are reproducing based on captures of larval fish; and razorback sucker larvae are surviving through the first years (Recovery Program, 2008). The May 2008 Recovery Program Assessment indicated "Larvae of stocked razorback are potentially surviving through the first year in the Gunnison River. Juveniles captured at Redlands were either produced in the wild or were stocked into Butch Craig."

Figure 4 presents the current distribution of razorback sucker in the action area. Recent surveys of stocked razorback sucker in the Gunnison River indicate stocked fish have been at large for 5-11 years (McAda and Burdick 2006, 2007). Repeat observations of razorback sucker in backwater habitats were made near RM 51.4 during 2006 and 2007, although one fish was caught upstream of the Delta highway bridge and one near the mouth of Roubideau Creek. Overall there is little evidence of successful recruitment of this species in the Upper Colorado River Basin, although recent surveys indicate that stocked razorback sucker are spawning successfully in the Gunnison and Colorado rivers (Osmundson and McAda 2006, 2007).

In the Colorado River, most razorback suckers have been captured in the Grand Valley reach of the Colorado River (Loma to Palisade) near the confluence of the Gunnison and Colorado rivers (McAda 2003). In the late 1970's, razorback sucker were frequently captured from gravel pit ponds connected to the mainchannel Colorado River (Kidd 1977; McAda and Wydoski 1980). Their abundance in those areas has decreased considerably since that time. Only 11 wild razorback sucker were captured from the

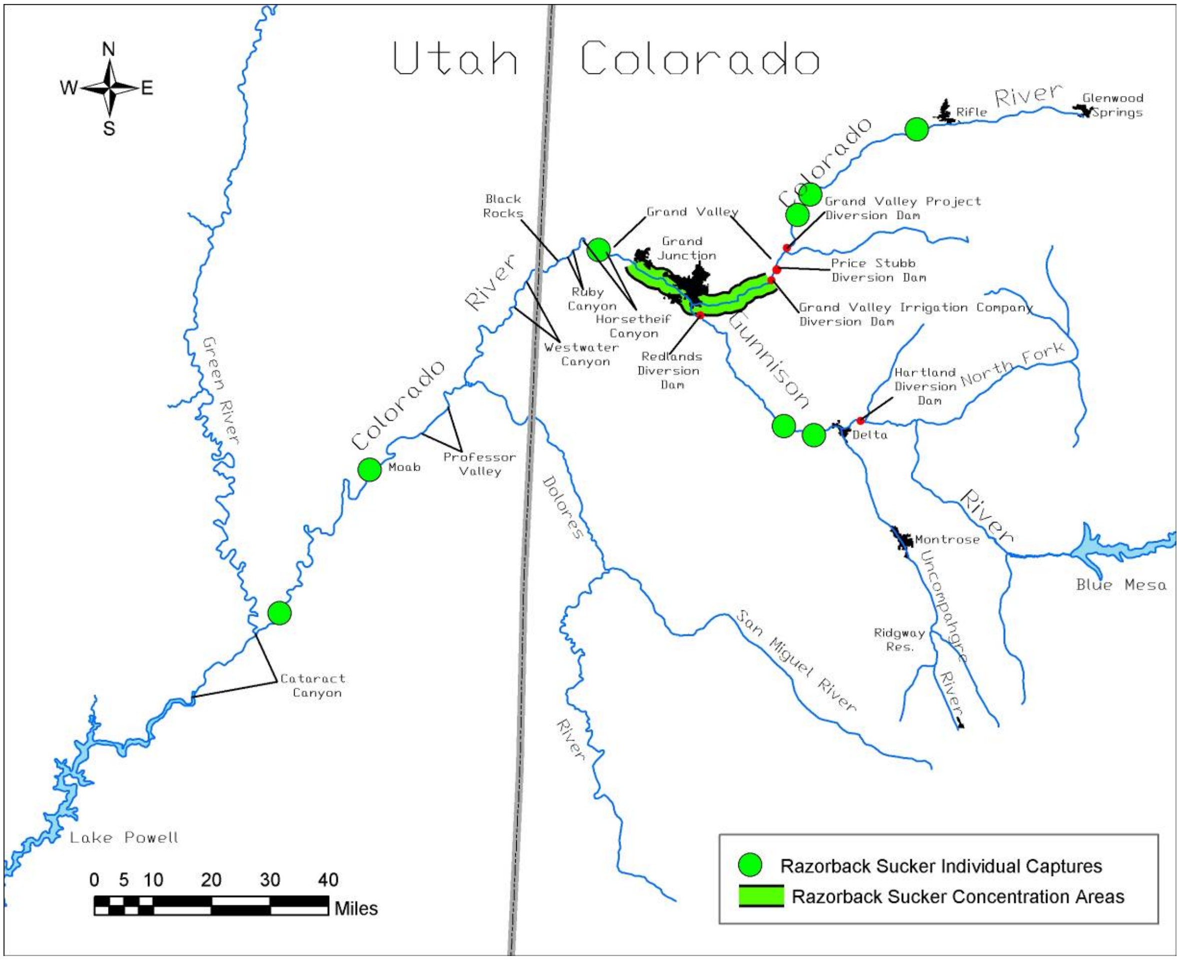


Figure 4. Razorback sucker distribution information, Colorado and Gunnison rivers.

Colorado River since 1990 (Osmundson and Kaeding 1991), all of which were brought into captive propagation programs.

Razorback sucker were also captured in considerable numbers near DeBeque in 1974-1975 by Kidd (1977). No razorback sucker captures have been made in that area since, although Burdick (1992) documented low numbers of fish in gravel pit ponds upstream and downstream of DeBeque. Few razorback sucker occur below Loma.

4.2.2.3 Life history

Adult razorback sucker attain a maximum size of about 1 m TL (5–6 kg; (Minckley 1973) and can exceed 40 years in age (McCarthy and Minckley 1987), although most individuals are less than 650 mm. Growth of razorback sucker is variable, depending on environmental conditions. Razorback sucker reared in hatchery aquaria were 150 mm TL in their first year of life (Valdez et al. 1982b), but fish reared in outdoor ponds near Vernal, Utah, grew to 127–156 mm TL in 4 months (Bestgen 1990). Fish reared in riverside ponds near Grand Junction, Colorado, grew from an average of 54.8 mm TL to 307 mm TL in 6 months (Osmundson and Kaeding 1989).

Most observations of razorback sucker reproduction in the Upper Colorado River Basin have been made in the Green River near Jensen, Utah. These fish spawn in May–June at temperatures of 6–19°C in velocities <1.0 m/s and depths of <1.0 m, near the upstream end of large gravel-cobble riffles (McAda and Wydoski 1980; Tyus and Karp 1990; Snyder and Muth 1990). Spawning sites occur in broad alluvial, flat-water regions with large cobble riffles and large riverside bottomlands as nursery areas immediately downstream (Bestgen 1990; Tyus and Karp 1989, 1990). Adults congregate in deep pools and runs near large cobble bars and spawn in April–May with rising water levels and increasing temperatures. Due to high reproductive potential and great longevity (McCarthy and Minckley 1987), razorback sucker may not spawn every year.

Newly hatched larvae (7-10 mm) drift into warm and highly productive flooded bottomlands, where they remain until the river recedes. The association of spawning during the ascending limb of the spring hydrograph and subsequent transport of newly hatched larvae into flooded bottomlands appears to be a critical relationship to the survival of this species that has been disrupted with regulation of high spring flows. Survival of newly hatched larvae appears to be the limiting factor for razorback suckers in the Upper Colorado River Basin (Tyus 1998). Absence of flooding that historically created flooded bottomlands in the Green, Yampa, and Colorado Rivers has limited nursery areas for newly hatched larvae (Bestgen 1990; Tyus and Karp 1990; Tyus 1998). Modde et al. (1996) correlated successful razorback recruitment in the Green River with high spring flows which reconnect floodplain habitats to the mainchannel.

Razorback suckers can migrate extensively to and from spawning sites in spring, but tend to move very little at other times of the year. As recently as the early 1980s, large numbers of adults were seen congregated at tributary mouths on the Green River (Tyus et al. 1982) and in gravel pits and large flooded bottomlands in the Colorado River (Valdez et al. 1982b). Except for spawning migrations, razorback suckers are relatively sedentary, moving only a few km over several months (Tyus 1987; Tyus and Karp 1990). Razorback sucker in the upper basin live sympatrically with about 20 species of warmwater, non-native fishes (Tyus et al. 1982; Lentsch et al. 1996) that are potential predators, competitors, and vectors for parasites and diseases. Hawkins and Nesler (1991) identified red shiner, common carp, fathead minnow, channel catfish, northern pike, and green sunfish as the non-natives considered by Upper Colorado River Basin researchers to be of greatest concern because of their suspected or documented negative interactions with native fishes. Sand shiner, white sucker, black bullhead, smallmouth bass, and largemouth bass were identified by Hawkins and Nesler (1991) as non-natives of increasing concern because of their increasing abundance, habitat preferences, and/or piscivorous habits. Lentsch et al. (1996) identified existing threats to native fishes in the upper basin from six species of non-native fishes including red shiner, common carp, sand shiner, fathead minnow, channel catfish, and green sunfish.

4.2.2.4 Razorback sucker habitat

Razorback suckers use different habitats with season and age (Valdez et al. 1987; Bestgen 1990; Tyus and Karp 1990). Habitat of (post-larval) juveniles has not been well documented because of small numbers of individuals captured in the wild. Juveniles (59–124 mm TL) have been captured in backwaters, tributary mouths, and flooded bottomlands (Taba et al. 1965). Adults over-wintered in deep runs and pools (0.6–1.4 m deep, 0.03–0.33 m/s) in alluvial and canyon regions of the Green River (Valdez and Masslich 1989), but often move into riverside gravel pits (Valdez et al. 1982b) and large flooded bottomlands during spring runoff for feeding and shelter from high mainstem flows (Tyus and Karp 1990). Adults in spring used deep, near-shore runs (0.6–3.4 m deep, 0.3–0.4 m/s), moved to large cobble islands (0.63 m deep, 0.74 m/s) for spawning, and shifted to shallow, slack water near mid-channel sandbars in summer (<2 m deep, 0.5 m/s) (Tyus 1987).

Temperature is an important aspect of habitat for razorback suckers. Thermal preference for adults was 22.9–24.8°C, based on electronic shuttle box studies, and lower avoidance temperature was 8.0–14.7°C and upper avoidance temperature was 27.4–31.6°C (Bulkley and Pimentel 1983). It was concluded from this study that alterations in year-round water temperature outside the range of 12.0–29.0°C should not be allowed if preservation of habitat for razorback suckers is a consideration.

Based on recent larval fish survey, spawning activity of stocked fish is taking place in the Gunnison River between the Redlands Diversion and Delta (Osmundson and McAda 2007). Larvae have been collected during most years since 2002, indicating successful reproduction. Locations of specific spawning sites have not been identified to date. Consequently, while the Recovery Program has identified and prioritized floodplain wetlands, their active restoration and management depends on proximity to these yet unknown spawning locations (Valdez and Nelson 2006). High priority floodplain habitats in the action area are identified in Section 2.1.1.

The relationship between flow regimes and habitat maintenance was summarized in McAda (2003):

<u>Spring</u>

- Increasing flows cue fish to migrate to spawning areas and trigger reproduction
- High flows inundate floodplain habitats to provide warm food-rich environments critical for larval fish and to provide river-floodplain connections
- High flows scour vegetation on banks and side channels to maintain habitat complexity
- High flows scour sediment from the cobbles and gravels to provide suitable location for eggs and larvae
- High flows mobilize the bed in runs and riffles; fines are flushed from the substrate and interstitial spaces
- High flows transport sediment and build in channel bars for backwater habitat
- High flows reduce non-native predators and competitors

<u>Late Spring/Early Summer</u>

- Declining flows allow increasing water temperatures
- Flows are sufficient to provide migration routes for adults and larvae

<u>Summer</u>
- Base flows maximize preferred habitat and sufficient depth for movement
- Base flows maximize backwater habitats available to young fish

<u>Winter</u>
- Base flows maximize preferred habitat and sufficient depth for movement and resting
- Base flows maximize backwater habitats available to young fish

4.2.3 Humpback chub (*Gila cypha*)

4.2.3.1 General

The humpback chub is a mid-sized cyprinid endemic to the Colorado River basin, generally found in deep-water canyon-bound reaches of the river system. Humpback chub were first listed as federally endangered on March 11, 1967 (32 FR 4001) and is protected under the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 *et seq.*). Critical habitat was designated on March 21, 1994 (59 FR 13374) as seven reaches (610 km) of the Colorado River System or about 28% of historic habitat

4.2.3.2 Historical distribution and abundance in the action area

Within the action area, humpback chub are most numerous in the Westwater Canyon and Black Rocks area of the Colorado River (McAda 2003). Westwater Canyon is an 18 mile reach comprised of rapids, deep pools and strong eddies; Black Rocks is a 1 mile reach just upstream of the Colorado-Utah state line. The two populations are generally considered isolated, although some limited movement between the two has been documented (Valdez and Clemmer 1982; Kaeding et al. 1990; Chart and Lentsch 1999a; McAda 2002b). The Westwater Canyon population has declined from 6,985 adults during 1993-1996 (Chart and Lentsch 1999) to about 2,413 fish in 2003 (Hudson and Jackson 2003; Recovery Program 2006b). Similarly, the Black Rocks population has declined from 764 fish in 1998 to 478 fish in 2003 (McAda 2007). In 2008, the Recovery Program estimated a population of about 3,000 adults in the Black Rocks and Westwater Canyon core populations (Recovery Program, 2008).

The Gunnison River has never been considered habitat for the humpback chub. Burdick (1995) captured one specimen in a canyon bound reach at RM 22. The Gunnison Gorge contains some habitat similar to other river reaches in the basin that support humpback chub, but only roundtail chub were documented during pre-impoundment surveys (Wiltzius 1978).

4.2.3.3 Humpback chub habitat

Canyon-bound reaches of deep water such as at Black Rocks and Westwater canyons are preferred habitat of humpback chub adults (McAda 2003). They appear to prefer low-velocity habitats adjacent to the main channel, primarily eddies. Humpback chubs spawn in late spring or early summer at, or shortly after the spring peak, generally mid-June to late July. Little is know about spawning but limited data indicates that spawning occurs in gravel and cobble substrates. Larval drift does not appear to be as significant as with the pikeminnow and razorback.

4.2.4 Bonytail (*Gila elegans*)

4.2.4.1 General

The bonytail is a large cyprinid fish endemic to the Colorado River and is the rarest of the four big river endangered fishes in the Colorado River Basin; wild populations are considered nearly extinct.

4.2.4.2 Historical distribution and abundance

The Gunnison River has never been confirmed as habitat for this species; however, early sampling and anecdotal information suggests the species was common in the Green and Colorado Rivers in the early 20th century (McAda 2003). The Fish and Wildlife Service (2002) cited one capture in the Gunnison River near Delta by Jordan (1891), although identification of this specimen has been questioned and 5 captures in the mainstem Colorado River in the 1980's. Therefore it is possible that the species once utilized the Gunnison River. In recent years the species has been stocked in backwaters adjacent to the river near Whitewater and Kowalski (2008) reported collecting 2 bonytail from the river near the backwater in the summer of 2008.

4.2.4.3 Bonytail habitat

Because the bonytail is so rare in the wild, little is known about habitat preferences (McAda. 2003). Limited captures have occurred in canyon sections such as Cataract Canyon and Black Rocks on the Colorado and canyon sections of the Green River. Because the bonytail evolved in the same system as the pikeminnow and razorback, it is assumed that similar flow regimes would be beneficial to all species.

4.3 Historical Habitat Changes

The baseline habitat of the four listed species has changed significantly over the last 125 years. Sections of this report document the significant changes in the hydrology, geomorphology, and water quality, including water temperature, of the Gunnison River and further information is found in McAda (2003). It is not entirely clear when populations of endangered fish declined in the Gunnison River and this makes the direct cause of the decline difficult to identify. Habitat changes related to flow changes, non-native fish, migration blockage, water quality, and river channelization all may play a part in the decline of the species.

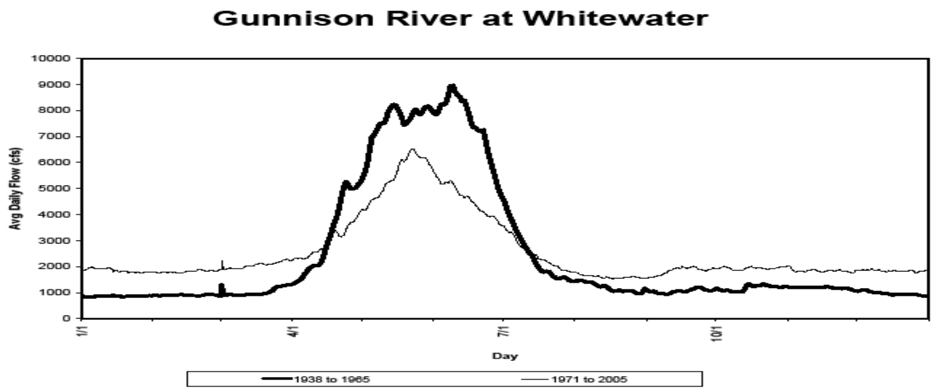
River flows

Pitlick et al. (1999) reported that since 1950, annual peaks of the Colorado River near Cameo have decreased by 29 % and annual peaks of the Gunnison near Grand Junction decreased by 38 %. Mean annual flows of the Gunnison have not changed significantly since 1950, while annual flows of the Colorado River have decreased significantly due to transmountain diversions. As an indication of increased summer and winter flows following construction of the Aspinall Unit, the percentage of months flows exceed 300 cfs downstream from the Redlands Diversion have increased from 43 to 65 % for August; 32 to 85% in September; 49 to 88% in October; 64 to 83% in December; 12 to 79% in January; 20 to 80% in February; 43 to 82% in March; and 85 to 90% in April.

Figure 5 provides a generalized picture of monthly flow changes in the Gunnison River over various time periods at Whitewater and in the Black Canyon. Long-term changes in climatic conditions, along with increased diversions for irrigation explain some of the differences in annual runoff at the Gunnison Tunnel. For example, the average annual natural flow of the Gunnison River at the Gunnison Tunnel between 1938 and 1965 was 185,940 af less than the period between 1911 and 1937. Overall, the 1992-2003 period was drier than the other periods. In addition, average Gunnison tunnel irrigation diversions increased by about 83,000 af per year in the same 1938-1965 period. However, changes in the seasonal distribution pattern of flows depicted by the hydrographs are due mostly to reservoir storage patterns.

Changes in flow regimes affected backwater habitats, channel maintenance, sediment movement, and other habitat factors. McAda (2003) summarized investigations into the influence of water development on channel morphology and river habitat:

> Pitlick et al. (1999) documented large-scale morphological changes that have occurred in parts of the Gunnison (lower 60 mi) and Colorado rivers (15-mi reach, 18-mi reach, and Ruby-Horsethief Canyon) by comparing aerial photographs taken in 1937, 1954, 1968, 1993, and 1995. The largest changes were in the 15- and 18-mi reaches where the Colorado River is largely unconstrained and still free to move about the floodplain (Pitlick et al. 1999). Although main channel and side channel area increased in some river segments, the overall trend was a decrease in surface area with main channel area decreasing by 15%, backwater area decreasing by 9% and side channel area decreasing by 26% (Pitlick et al. 1999). The reduction in side channel habitat may be especially important because side channels increase habitat diversity even though they comprise a small percentage of the river. Complex river reaches (i.e. multi-thread reaches) provide a variety of habitats in a small area and are preferred over single-thread reaches by adult Colorado pikeminnow. The 15- and 18-mi reaches provide most side-channel habitat in the Colorado River (Pitlick and Cress 2000) and contain a much higher number of adult Colorado pikeminnow than other, much longer reaches of the river.



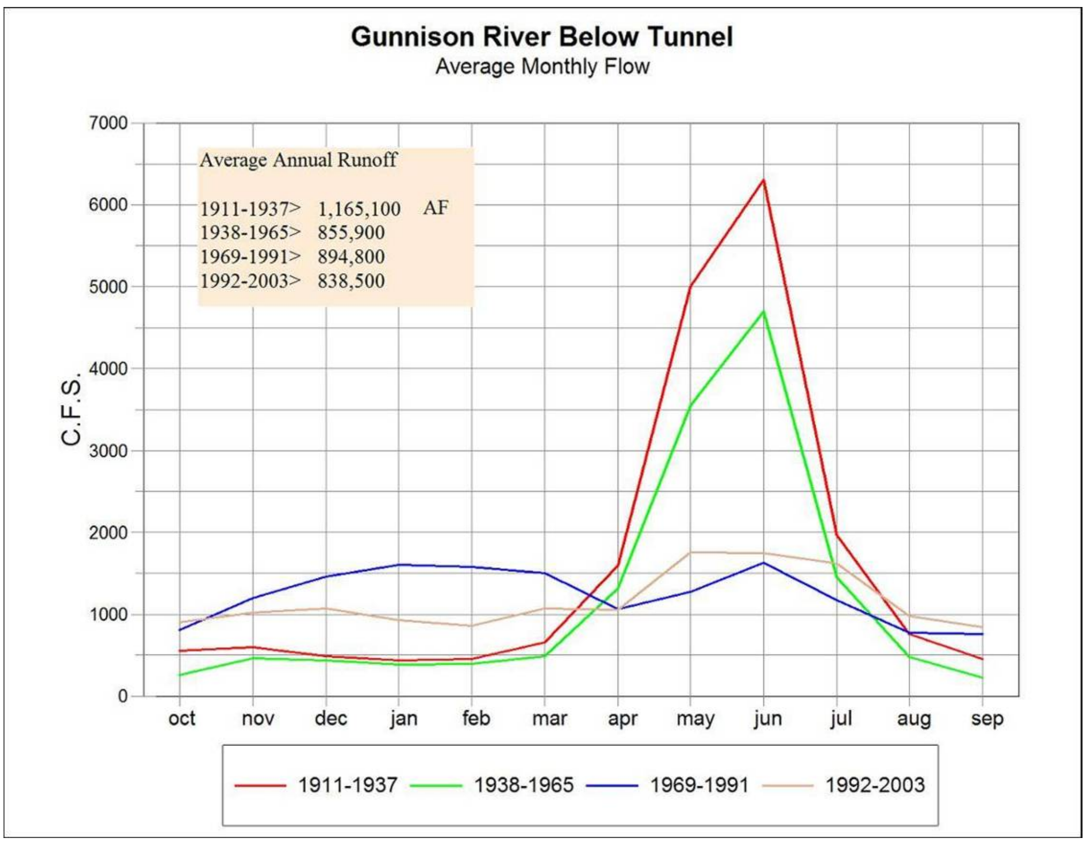


Figure 5. Generalized presentation of average monthly flow changes, Gunnison River at Whitewater and in Black Canyon.

Change in the channel area of the Gunnison River was less than observed for the Colorado River, but results were probably underestimated because of large differences in river flow when the two sets of aerial photographs were taken (Pitlick et al. 1999). Also the Gunnison River is more incised than the Colorado River and less change would be expected. Pitlick et al.

(1999) documented little change in main channel and side channel area, but showed a 15% decrease in island area between 1937 and 1995.

Geomorphology

While spring peak flows have decreased in the rivers, sediment inflow to the rivers apparently has not (Pitlick et al. 1999, Pitlick and Cress 2000). These two interacting factors reduce channel complexity as side channels gradually fill with sediment. Overall the rivers can become narrower and more simplified. This tendency is magnified by construction of dikes and other channel control structures. According to Pitlick et al. (1999), the period from the late 1950's through the 1970's had lower peak flows and similar annual sediment loads than occurred before or after that period, and this may have resulted in substantial sediment deposition in fish habitat, thus affecting spawning areas and backwaters. Very high flows, such as occurred in 1983 and 1984 tend to reverse the process temporarily.

Sediment deposition may also adversely affect the carrying capacity of rivers for the endangered fishes by reducing periphyton and macroinvertebrates that are important parts of the riverine food web (Osmundson et al. 2002) and Lamarra (1999).

Migration

Prior to water development in the basin, it is assumed that fish freely moved between the Gunnison and Colorado rivers; however, early water projects cut off these movements. The Redlands Diversion, located 3 miles upstream from the Colorado River confluence, was a barrier to upstream fish migration to the Gunnison River for nearly 100 years; and, during base flow periods, diverted a significant portion of the river and also presumably larval and adult fish. The Hartland Diversion, upstream from Delta, to a lesser extent, was also a barrier to migration. On the mainstem Colorado River migration was precluded by Boulder Dam in 1935 and by subsequent dams including Glen Canyon. Diversion Dams on the Colorado River upstream from the Gunnison confluence in Mesa County Colorado also blocked migration. In the last decade, fish passage has been provided around the Redlands Diversion and through the diversions on the Colorado River upstream from the Gunnison confluence. In addition fish screens have been constructed at major canals to reduce losses of fish to canals.

Water quality

While records are sparse, it is likely that water quality conditions in the early mining/timbering/grazing days were extreme and may have significantly affected fisheries. Mining in the headwaters and uncontrolled grazing in early settlement years affected water quality and streamflows, while large-scale irrigation in valleys underlain by Mancos shale resulted in return flows with increased salinity and selenium levels. Hamilton (1999) cited very high levels of selenium in the Colorado River basin early in the 20th Century. According to Hamilton, "In the 1930's selenium concentrations in various drains, tributaries and major rivers in the upper and lower Colorado River basins were in the 100s and 1000s of (ppb)." Levels of 80 ppb were reported from the mouth of the Gunnison River (NIWQP display based on Hamilton 1999).

The historical effect and the effect of present levels of selenium related to the recovery of endangered fish in the Green, Colorado, and Gunnison rivers has been a debated topic. Hamilton et al. (2000) suggested that survival and recruitment of razorback larvae in the Green River was limited due to selenium concentrations. Hamilton (1999) also hypothesized on the possible role of selenium in the decline of endangered fish species in the Colorado River Basin:

> In retrospect, the extremely elevated selenium concentrations in the Colorado, Gunnison, Uncompahgre, and San Juan rivers and their tributaries from the mid-1930's, which presumably started in the 1890s when irrigation activities began, would be expected to have had a devastating effect on native fish, based on adverse effects demonstrated in recent studies with endangered fish and numerous other species. This adverse effect was recognized indirectly as the disappearance around the 1910 to 1920 period of large-river fish such as Colorado pikeminnow and razorback sucker before large dams were constructed in the upper Colorado River basin. In the lower basin these fish were found until 1911 in abundance in irrigation ditches, but by 1925 to 1930 were considered scarce. The statement of Minckley et al. (1991) about the striking historical absence of young razorback sucker in collections suggests reproductive failure probably was occurring, i.e., no recruitment of young fish to the population, which is one of the well documented effects of selenium exposure. There is little doubt that the construction of mainstem reservoirs and introduction of exotic species have contributed to the decline of endangered fish in the Colorado River. There is now evidence that selenium, historically and currently, may be contributing to the endangerment of fish in the Colorado River basin.

In contrast to this study however, the Recovery Program also sponsored evaluations of selenium contamination on endangered fish during the mid- to late 1990's. Beyers and Sodergren (1999) conducted laboratory experiments on effects of direct exposure to dissolved and dietary selenium on survival and growth of razorback sucker larvae. They observed no changes in survival or growth or larvae due to exposure to selenium in any form or concentration, although dietary concentrations were likely insufficient to elicit a response. Predictions from this study were later validated by exposing razorback sucker larvae to water collected from three locations in the Colorado River near Grand Junction and food organisms cultured in that water, including higher levels of dietary selenium than used in the laboratory study (Beyers and Sodergren 2001a, b). As with the laboratory study, significant negative biological effects of selenium were not detected in razorback larvae. However, while the authors noted that selenium could be harmful if effects of maternal selenium transfer were considered, they recommended that the Recovery Program consider all threats to razorback sucker recruitment and survival (i.e., loss of physical habitat, altered thermal and hydrologic regimes and interactions with non-native fish) in their formulation of management actions.

Other studies concluded that most of the evidence implicating selenium is circumstantial and that “neither the historical record nor the technical literature consistently supports the emphasis given selenium toxicity (Korte 2000).

Much like other deep-release dams, Blue Mesa Dam has decreased the summer temperatures of the Gunnison River and increased winter temperatures. Summer temperatures below the North Fork have declined by as much as 10 degrees C in the summer (Stanford 1994), but due to rapid warming rates below that point temperatures near Delta are only 2 degrees C below pre-dam levels (McAda and Kaeding 1991). Temperatures reach pre-dam levels where the Gunnison enters the Colorado River, and the latter is not thermally affected by the Aspinall Unit (McAda 2003).

Backwaters

Development of towns such as Delta, the railroad that parallels the river downstream from Delta, and individual orchards and farms along the river led to the construction of dikes and bank protection measures all along the Gunnison River and to filling in or cutting off backwater areas. Irving and Burdick (1995) estimated that bottomland habitat availability was much more common prior to dike construction and flow regulation. The loss of backwaters may be of particular importance to the razorback sucker. The razorback spawns in the spring as flows increase and eggs hatch 1-2 weeks after spawning. Larvae are thought to drift into backwaters and floodplains that provide early critical habitat for the young fish. Backwaters were once extensive in the Delta area and have been reduced; this habitat has also been reduced downstream from the Roubideau confluence area but was probably never common. Flows above 10,000 cfs increase backwaters and flooded habitat. The frequency of years having flows greater than 10,000 cfs decreased from 57 % to 33 % following construction of the Aspinall Unit based on the period between 1937 and 1997. Similar channel modification developments occurred along the Colorado River, particularly in valley reaches.

Non-native species

Non-native fish have been introduced to the Gunnison and other basin rivers and now species such as the white sucker, common carp, red shiner, sand shiner, fathead minnow, and green sunfish are common in endangered fish habitat. Fifty-two fish species occur in the Upper Basin, but only 13 of those are native species (Fish and Wildlife Service 2000). Competition with and predation from the non-natives affect the endangered fish species. Tyus and Saunders (2001) discussed how competition and predation by introduced fishes has emerged as a major biotic factor limiting the survival and recovery of endangered fish populations. Overall, however, the Gunnison River appears to have a higher percentage of native fish (such as roundtail chubs and bluehead and flannelmouth suckers) than other upper basin rivers. The CDOW surveyed the Gunnison River in 2008 and reported a high percentage of native fish with bluehead, roundtail, and flannelmouth common (Kowalski, 2008).

There is some belief that the Redlands Diversion may have impeded the spread of non-natives such as channel catfish and largemouth bass upstream into the Gunnison. Brown trout and to a lesser extent rainbow trout are common in the Gunnison River upstream from Austin and occasionally occur in critical habitat downstream from Delta. McAda (2003) reported that there is some evidence that high spring flows may reduce the abundance of some non-native fish. Burdick (2005) found that young of native fish composed a much higher percentage of the fish population in Gunnison River backwaters in the high water year of 1993 than in the low water year of 1992. The introduced species may be less able to survive the high flows than native fish. Even if this reduction is temporary, it may increase the survival of young native fish.

Non-native vegetation may also affect the fish. The non-native shrub tamarisk has become established along most of the Gunnison and Colorado rivers, facilitating stabilization of river banks.

4.4 Critical Habitat and Recovery Goals

Critical habitat for the Colorado pikeminnow and razorback sucker was designated in 1994. Overall 1,980 miles of rivers were designated. "Critical habitat," as defined in section 3(5)(A) of the ESA, means: ``(i) the specific areas within the geographical area occupied by the species at the time it is listed, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (III) specific areas outside the geographical area occupied by a species at the time it is listed, upon a determination by the Secretary that such areas are essential for the conservation of the species."

Designated critical habitat for the razorback sucker makes up about 49 % of the species' original range and occurs in both the Upper and Lower Colorado River Basins. Critical habitat for the Colorado pikeminnow makes up about 29 % of the species' original range and occurs exclusively in the Upper Colorado River Basin (FR 59 13374-13400). Critical habitat for both species includes the Gunnison River and its 100-year floodplain from the Uncompahgre River confluence to the Colorado River confluence (Figure 6). In Colorado and Utah critical habitat includes the Colorado River from the town of Rifle to Lake Powell; the Gunnison River from Delta to the Colorado River confluence; the Yampa River from Craig to the Green River; the White River from Rio Blanco Dam to the Green River; and the Green River from Dinosaur National Monument to the Colorado River confluence.

Critical habitat was also designated for all four endangered fish species within portions of the Colorado River in Colorado and Utah. Critical habitat for Colorado pikeminnow in Colorado extends from the town of Rifle to Lake Powell. Razorback sucker critical habitat extends from Rifle, Colorado to Westwater Canyon. Humpback chub and bonytail

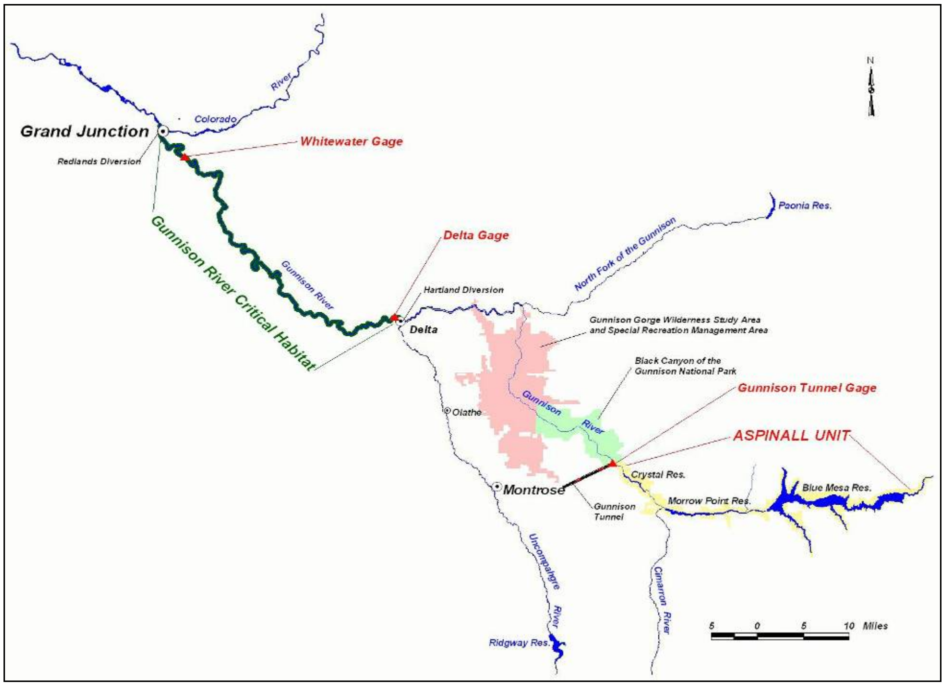


Figure 6. Critical habitat, Gunnison River.

critical habitat includes the Colorado River from Black Rocks to Fish Ford and Cataract Canyon in Utah.

Recovery goals, that define when species may be downlisted or delisted, were established for the species in 2002; these goals essentially call for establishing self sustaining populations. Goals are defined as population numbers, recruitment, and trends in the Green and Upper Colorado River. There are no specific goals for the Gunnison River, and Gunnison River populations would be included in the Upper Colorado River numbers. Recovery goal details are included in Attachment 7. At the present time, goals are being updated.

Recovery Goals for razorback sucker and Colorado pikeminnow recommend continued operation of the Redlands Fish Ladder and feasibility studies on increasing Gunnison River water temperature as site-specific management actions to address listing factors, and assessment of effects of selenium contamination are also identified for the entire Colorado River basin. The Recovery Program continues to fund and operate the Redlands Fish Ladder on an annual basis as part of its regular operation and maintenance budget. The Program also funded completion of two feasibility studies on potential modification of Aspinall Unit operations or infrastructure to increase water temperatures in the Gunnison River and expand endangered fish range, but have made no decision to date on the necessity of such actions for recovery.

4.5 Activities to benefit the species

The Recovery Program has overseen research activities on the endangered fish of the Gunnison River, with field studies being initiated in 1992. One end product of these investigations was publication of flow recommendations (McAda 2003) for the Gunnison and Colorado (downstream from the Gunnison confluence) rivers to benefit the endangered species.

The Aspinall Unit provided research flows during 1992-1998 for the Recovery Program studies, during which time release of excess water was reconfigured to provide a maximum release at Crystal Reservoir of 4,000 cfs. Duration and magnitude of releases varied greatly with inflow volumes. Since that time, Reclamation has implemented similar management of “risk of spill” water to benefit the endangered fish. The extended drought of the early 2000’s has limited magnitude and duration of spring peaks, however. Studies completed during the research period included surveys of distribution and abundance of endangered fish in the Gunnison River (Burdick 1995); assessment of Gunnison River flows on Colorado pikeminnow larvae and nursery habitat in the Colorado (Anderson 1999; Trammell and Chart 1999a, b); changes in the geomorphology of the Colorado and Gunnison river channels (Pitlick et al. 1999); effects of research flows on young-of-year Colorado pikeminnow (McAda and Ryel 1999); response of endangered fish habitat to research flows (McAda and Fenton 1998); effects on humpback chub in Westwater Canyon (Chart and Lentsch 1999); and impacts of research flows on geomorphology and food web dynamics in the Colorado River (Lamarra 1999; Osmundson 1999; Pitlick and Cress 2000).

Results from the research period and other studies were utilized through a weight-of-evidence approach to develop the flow recommendations for the Colorado and Gunnison rivers (McAda 2003). Specific relationships between biological response and river flow were used to quantify the underlying causes for biological responses, with considerable emphasis on flow response of riverine habitats critical to endangered fish. Partial restoration of natural functions through mimicry of a natural hydrograph was hypothesized to benefit endangered fish and physical and biological resources they rely on (Stanford 1994; Stanford et al. 1996; Poff et al. 1997).

Control of non-native fish in the Colorado and Gunnison rivers began in 1995-1996, during which time small numbers of northern pike were removed from the Gunnison River with electrofishing, fyke nets and trammel nets (McAda 1997). The effort proved successful at suppressing northern pike range expansion in the Gunnison River due to low or nonexistent in-stream recruitment. More recently, increased numbers of smallmouth and largemouth bass in the Colorado River has prompted the Recovery Program to begin aggressive mechanical removal programs in the Grand Valley reach. While numbers of smallmouth bass have apparently declined following these efforts, numbers of largemouth bass have increased (Burdick and McAda 2007).

The Recovery Program has established hatchery and grow-out facilities, and stocking of Colorado pikeminnow and razorback sucker began in the Gunnison and Colorado Rivers in the 1990's in an effort to establish reproducing populations. A total of 49,954 razorback sucker (ranging from 100 to 300 mm in length) were stocked in the Upper Colorado (31,531) and Gunnison (18,423) rivers from April 1994 through October 2001 (Burdick 2003). Fish stocked at a minimum of 200 mm total length were recaptured most frequently. Larval fish monitoring indicates that these stocked razorback sucker are reproducing successfully.

Since 2001, 5,483-12,906 razorback sucker were stocked annually in the Colorado River and 549-3,805 were stocked in the Gunnison River (Tom Czapla, UWFWS, personal communication). The current stocking target for the Colorado and Gunnison rivers combined is 9,930, with the Colorado receiving about two-thirds of the fish. During that same period, stocked bonytail varied from 3,985 to 37,968 fish/year and the current target is 5,330 fish/year. Due to relative abundance of wild Colorado pikeminnow, stocking rates of this species are much lower (1,125 fish/year each in the Colorado and Gunnison rivers) and stocking occurred only in 2003 and 2004. To date, the Recovery Program has not determined the future of the Colorado pikeminnow stocking program.

Habitat improvements have been completed on the Gunnison River. A fish ladder was constructed around the Redlands Diversion and has been operated successfully since 1996; between 1996 and 2008 the ladder was used by 102 pikeminnow, 24 razorback suckers, 1 bonytail, and almost 86,000 other native fish (Recovery Program 2008). Recaptures have shown that there is some movement both upstream and downstream past the Redlands Diversion. A fish screen has been installed on the Redlands Canal to reduce losses of native and endangered species in the canal. Bottomland/floodplain habitat has been improved near Whitewater and Delta to increase nursery habitat for young fish. Fish passage, backwater protection, habitat improvement, and improved flows have also been implemented on the Colorado River mainstem. Growout ponds for razorback suckers have been constructed along the Gunnison River and are operated by the Service using water diverted from Gunnison River.

The Recovery Program has investigated the feasibility of warming releases from the Aspinall Unit (Hydrosphere 2002; Boyer and Cutler 2004). The two feasibility studies concluded that it was possible to meet downstream temperature targets for Colorado pikeminnow and razorback sucker (ca. 1-2 °C warmer than current conditions) through construction of a selective withdrawal structure on Blue Mesa Dam. However, uncertainties associated with model error, the status of the Gunnison River fish community and blockage of upstream migration routes at Hartland Diversion Dam prompted the Recovery Program to table discussions on construction of such a withdrawal structure until uncertainties are resolved.

A Coordinated Reservoir Operations Program (CRO; Recovery Program 2006a) was established through the Recovery Program to identify operational flexibility in existing water storage reservoirs that could collectively be used to enhance peak flows in the 15-Mile Reach of the Colorado River to benefit endangered fish species and their habitats without reducing project yields, increasing costs or affecting a project's water rights. CRO participants requested official Recovery Program concurrence with the CRO concept and process, and the latter were approved by the Recovery Program Management Committee in 2006. Implementation of the CRO process has proven to be possible during most years since 1997. In 1998 and 1999, a total of 65,000 af was released to support spring flows, which on average increased spring peaks by 2,000 cfs. Apparently these contributions were sufficient to mobilize small proportions of the bed in the 15- and 18-mile (Gunnison confluence to Loma) reaches, and overall CRO can assist in providing flows to achieve sediment mass balance and avoid channel narrowing (Pitlick 2007).

Recovery Program activities in the Gunnison River are primary directed toward the Colorado pikeminnow and razorback sucker and no specific activities are designed for the humpback chub or bonytail. However, the two species are included in the flow recommendations (McAda 2003) which the Recovery Program has approved. These recommendations acknowledge the role of Gunnison River flows in the maintenance and improvement of habitat conditions in the Colorado River, where humpback chub and possibly bonytail are present. It is also possible that operation of the Redlands Fish Ladder may allow humpback chub or bonytail to occupy new habitat, and as noted previously bonytail have been stocked in Gunnison River backwaters.

5.0 OTHER SPECIES

5.1 Vegetation

5.1.1 Clay-loving wild buckwheat (*Eriogonum pelinophilum*)

The clay-loving wild buckwheat is a small shrub that is found in semi-desert shrub communities of adobe hills. It is normally located in specific microhabitats and can be associated with shadscale and mat saltbush. Its range is restricted to small acreages in Delta and Montrose Counties and primary threats include fragmentation or clearing of habitat for urban development and off-road vehicle use. In the early 20th century, habitat was probably more extensive and was probably cleared for agricultural lands. Soils supporting the species are derived from Mancos shale (Lyon and Williams 1998).

The species is not associated with riparian lands along the Gunnison River and would not be affected by the proposed operation changes. The buckwheat does occur in the vicinity of laterals and canals on the eastern side of the Uncompahgre Valley. This is the same area where selenium/salinity control improvements are a priority. Consequently, Reclamation will survey all selected work areas in order to identify and avoid disturbing populations of this species.

5.1.2 Uinta Basin hookless cactus (*Sclerocactus glaucus*)

The Uinta Basin Hookless Cactus is a small cactus normally found on gravelly alluvial soils or in clay between 4,500 and 6,000 feet and can be associated with shadscale, sagebrush, greasewood, saltbush, and other desert vegetation. In Colorado it is reported from Montrose, Delta, Gunnison, Garfield, and Mesa Counties and is also found in Utah. Threats may include trampling from grazing, recreation use of lands, off-road vehicle use, and development on some lands. Past reports include populations on benches along the Gunnison River from Hotchkiss downstream (Lyon and Williams 1998). The species is not associated with riparian lands along the Gunnison River and would not be affected by the proposed action.

5.1.3 Jones' cycladenia (*Cycladenia humilis var. jonesii*)

The Jones' cycladenia is a small herbaceous perennial listed as threatened and restricted to the canyonland area of the Colorado Plateau in eastern Utah and a small portion of Arizona. This plant is found in gypsiferous soils in mixed shrub-pinon juniper communities. Threats include off-road activity and mineral development. The species is not associated with habitats that might be affected by the proposed action.

5.2 Wildlife

5.2.1 Western yellow-billed cuckoo (*Coccyzus americanus*)

The western yellow-billed cuckoo is a candidate for listing under the ESA. The species breeds in large blocks of riparian habitats, in particular cottonwood woodlands, and dense understory foliage appears to be important. Based on historical accounts, the species was localized and uncommon along Colorado drainages while being locally common in other western areas (Fish and Wildlife Service 2005). The species was probably never common in western Colorado and was considered extremely rare by Kingery (1998). In 1998, 242 miles of riparian habitat were surveyed along six rivers in west-central Colorado with only one cuckoo detected (Dexter 1998). In 2008 breeding of this species was confirmed along the North Fork of the Gunnison River; and cuckoos were observed during the breeding season at 6 locations near Hotchkiss and on 1 near Paonia (Beason 2008).

Cottonwood woodlands have been lost or fragmented in the study area due to clearing for towns and agriculture, filling and diking of lowlands, development of recreation sites in woodlands, fires, invasion of tamarisk and other non-native plants, and reduction of spring peaks that are important for regeneration of cottonwood stands.

Increased spring peaks with the proposed action may have some benefit to the regeneration of cottonwood stands which could provide habitat for the cuckoo; however, without long-term protection, cottonwood woodlands will continue to be degraded through other activities.

5.2.2 Mexican spotted owl (*Strix occidentalis lucida)*

The Mexican spotted owl is a threatened species and occurs in rocky canyons and forested mountains generally below 9,500 feet. The Mexican spotted owl has the largest geographic distribution of any of the *S. occidentalis* subspecies. Historically, the owl ranged from the southern Rocky Mountains in Colorado; the Colorado Plateau in southern Utah; southward through Arizona, New Mexico, and far western Texas; in Mexico through the Sierra Madre Occidental and Oriental mountains and the southern end of the Mexican Plateau. Presently, the owl's range reflects the historic range, but owl numbers are much reduced and habitat is patchy. The primary threat Mexican Spotted Owls face is the loss of mature trees to timber harvesting and to stand-replacement fires, especially in steep canyons and in riparian zones. Several blocks of critical habitat have been designated in Colorado outside of the project area. Potential habitat for the species occurs in the project area; however, the proposed action would have no effect on this habitat.

5.2.3 California condor (*Gymnogyps californianus)*

The California condor is an extremely rare member of the vulture family. By 1982 only 22 condors existed and a captive breeding program began. The species was reintroduced to the Colorado Plateau in 1996 with the release of 6 birds in northern Arizona. Recovery goals include establishment of geographically separate populations in California and Arizona. Threats include lead poisoning, collisions with powerlines, and shooting. Released birds have made intermittent travels into the project area; however, there is no long-term use. Potential habitat for the species would not be affected by the proposed action.

5.2.4 Southwestern willow flycatcher (*Empidonax traillii extimus*)

The southwestern willow flycatcher nests in dense riparian vegetation and are thus vulnerable to impacts associated with modification of riparian habitats such as channelization, recreational development, grazing, and agricultural conversion (Kingery 1998). The subspecies does not occur in the Gunnison Basin but potential habitat occurs in the Dolores and Lower Colorado river basins. Critical habitat has not been proposed in the project area.

Increased spring peaks with the proposed action in the Colorado River may have some minor benefit to the regeneration of cottonwood and willow riparian stands which could provide habitat for the willow flycatcher; however, overall no effect is projected on this subspecies.

5.2.5 Black-footed ferret (*Mustela nigripes)*

The black-footed ferret is one of the most endangered mammals in North America. The ferret is associated with prairie dog towns and was once believed extinct. A reintroduction program is underway, including introductions in northwest Colorado. At the present time, there are no known populations in the Gunnison Basin. Potential habitat is fragmented in the basin, with prairie dog towns separated by cropland and other human developments. Historical presence in the basin is not known. The proposed action should have no effect on this species or its potential habitat.

5.2.6 Canada lynx (*Lynx canadensis*)

Lynx may have disappeared from Colorado by about 1973. Sightings prior to that time were few, scattered throughout mountainous areas of the state. In 1999 a program of lynx restoration began in the San Juan Mountains, and by 2005 more than 200 animals had been released, a number of litters of kittens had been born, and lynx were expanding throughout the high country and occasionally beyond. Lynx reproduction has not been confirmed in 2007 and 2008, possibly related to snowshoe hare declines. The lynx is found in dense sub-alpine forest and willow corridors along mountain streams and avalanche chutes, the home of its favored prey species, the snowshoe hare.

Reintroduced lynx have entered the Gunnison Basin where potential habitat occurs at higher elevations. The potential exists that the species will become permanently established in the basin.

The proposed action should have no effect on existing lynx populations or potential habitat.

5.2.7 Gunnison's prairie dog (*Cynomys gunnisoni*)

The Gunnison's prairie dog lives along the Colorado Plateau in southeastern Utah, southwestern Colorado, and portions of New Mexico and Arizona. Certain populations, including some in the Gunnison Basin, are considered as a candidate for listing under the ESA. Populations are considered to occur in two range portions – montane populations at higher elevations and prairie populations at lower elevations. The montane populations are considered as candidates for listing.

Habitat for the montane populations includes plateaus, benches, and intermountain valleys with grass-shrub-mountain meadow vegetation. There is an approximately 250 acre colony in the Curecanti Recreation Area at Blue Mesa Reservoir. Many factors influence populations including urban and agricultural development, other land conversions, grazing, poisoning, and recreational shooting; however, sylvatic plague is the most significant factor. This plague is a non-native pathogen that arrived in North America around 1900 (Seglund et al. 2005, Fish and Wildlife Service 2008).

The proposed action should have no effect on populations or habitat of this species.

5.2.8 Uncompahgre fritillary butterfly *(Boloria acrocnema)*

This butterfly is listed as endangered and has a very small known range in the mountainous areas of Gunnison, Hinsdale, and Chaffee counties of southwestern Colorado. All known colonies are associated with patches of snow willow above 12,500 foot elevation.

The proposed action should have no effect on populations or habitat of this species.

6.0 EFFECTS OF THE ACTION ON LISTED FISH

6.1 General

Water development and uses, along with other human activities; have probably been affecting the endangered fish species since the end of the 19th century. Early water uses greatly depleted base flows and water quality problems probably peaked early in the 20th century as new irrigation lands were developed, pollution from mining was high, and grazing and other land uses were largely unregulated (see Section 3.4.3 for more discussion).

6.2 Methodology

Existing information on potentially affected species was reviewed and appropriate information summarized for this report. Alternative Aspinall Unit operation modeling runs were conducted and reviewed with the Fish and Wildlife Service as part of informal Section 7 consultation on the effects of new operations on the endangered fish. During this consultation, peak flows, flow duration, flows downstream from the Redlands Diversion, and base flows were considered as well as concerns with factors such as potential flooding in the Delta area. Information on hydrology modeling is found in Section 3.4 and Attachment 12 and in the draft EIS for Aspinall reoperations.

Changes in habitat conditions, such as channel morphology and backwater availability related to flow changes, were then considered along with effects on water quality, non-native species, and other factors. Flows under the proposed alternative were also compared to the goals of the Flow Recommendations.
This section includes an analysis of the direct and indirect effects of the proposed action, its interrelated and interdependent activities on species and critical habitat. Cumulative effects are considered by assessing the effects of future actions reasonably likely to occur in the area.

While construction of the Aspinall Unit and other public and private water projects are not addressed in this PBA, the ongoing effects of operating the Aspinall Unit and other water uses are. In regard to endangered fish, these ongoing effects are reflected in the baseline and include habitat changes related to reducing spring peaks in critical habitat and increasing base flows, cooling summer water temperatures, and reducing concentrations of water pollutants by reservoir releases in low water periods.

The proposed action would have beneficial effects on the four listed Colorado River fishes and their critical habitat within the action area when compared to the baseline. Benefits result from the increased frequency, magnitude, and duration of spring peak flows and protection of base flows. The flow changes will assist in improving and maintaining habitat conditions for spawning and recruitment and for maintenance of adult pikeminnow and razorback sucker habitat. For Colorado pikeminnow (and probably other endangered fish), Osmundson and Burnham (1998) reported that the success of recovery efforts will largely depend on providing environmental conditions that increase reproductive success and survival of early life stages. In general, the implementation of a flow regime that more closely resembles a natural flow regime of the river will provide benefits to the endangered fish and their habitat.

6.3 Flow and Habitat Effects

Table 11 and Figure 7 summarize a comparison of baseline and proposed action peak flows and Table 12 presents a comparison of the frequency of selected flows. Detailed information is contained in Attachment 8.1 and 8.2. It should be noted that mean daily peak flows are presented; instantaneous peaks would be higher. As discussed previously in this assessment, flows adequate to move sediment through the Gunnison River system are crucial to maintaining and improving critical habitat for the listed fishes. Reaching flows that are half bankfull or bankfull is considered key in the sediment movement. Goals of 8,070 and 14,350 cfs were established in the Flow Recommendations. At a flow of 8,070 cfs one-half (27) of the river cross sections identified by Pitlick et al. (1999) reach half bankfull (initial motion) and at 14,350 cfs one-half of the river cross sections reach bankfull (significant motion). As can be seen in Tables 12 and 13 and Attachment 8.4-8.5, the number of days that flow reaches these thresholds increases as well as the frequency of the years they are reached.

Table 11. Summary of peak flows (mean daily) at Whitewater gage for study period, baseline and proposed action.

	Baseline	Proposed action
Mean May peak flow (cfs)	8,551	10,124
Mean June-July peak flow (cfs)	7,448	8,310

Table 12. Percentage of years in study period when selected flow levels are exceeded at the Whitewater gage during the spring runoff. Half bankfull and bankfull highlighted.

Flow (cfs)	Percentage of years selected flow exceeded	
	Baseline	Proposed action
6,000	61	77
7,000	55	77
8,070	52	61
9,000	45	52
10,000	35	48
11,000	29	45
12,000	26	35
13,000	26	29
14,000	19	26
14,350	19	26

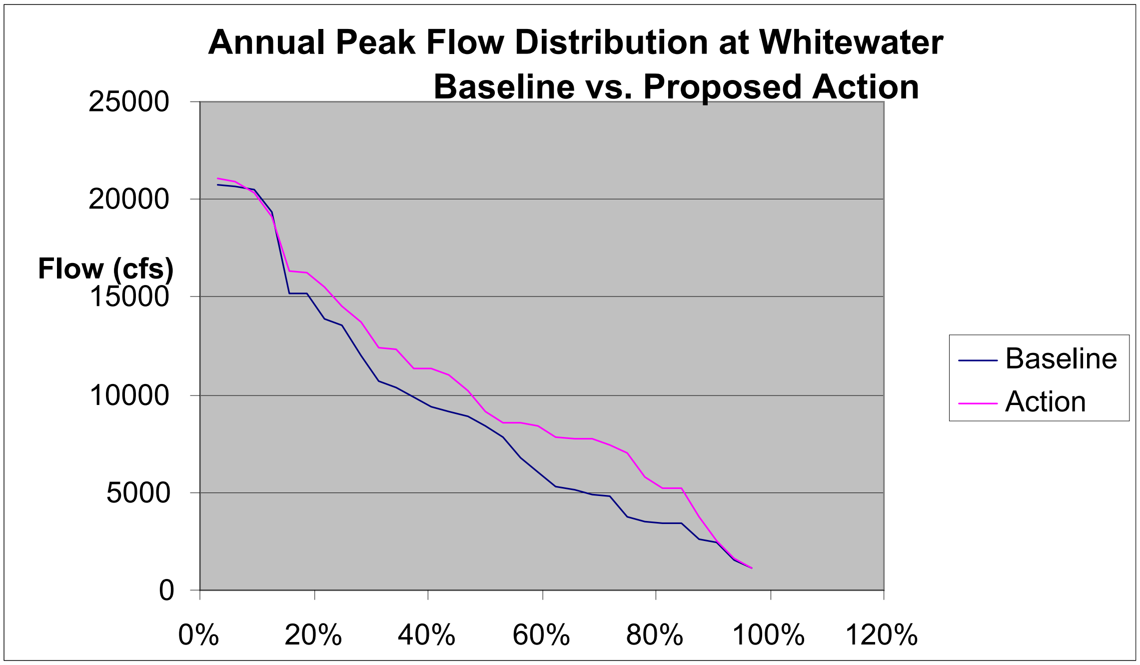


Figure 7. Expected frequencies of peak flows at Whitewater Gage under Baseline and proposed action conditions.

Under the proposed action, peak flows would be greater and occur more frequently than baseline peak flows. Proposed Action mean peak flows in May would be about 10,124 cfs, or 18% greater than the baseline peak (8,551 cfs). This average peak magnitude is more approximate of natural conditions, indicating a return to less regulated flow conditions. Peak flows equal to or greater than initial motion threshold flows (8,070 cfs; Pitlick et al. 1999) should occur during 19% more years under the proposed action than under the baseline, and flows equal to or greater than significant motion threshold flows (14,350 cfs) should occur during 33% more years than under baseline condition.

It should be noted that flows above and below target flows also provide benefits to habitat (Table 6 and Attachment 4). Table 13 shows the percentage of transects (Pitlick et al. 1999) where half bankfull and bankfull flow elevations were attained over a range of discharge and the relative gain in frequency of days at these flows under baseline and proposed action. The greatest gain (24%) occurs in average number of days at or above 10,000 cfs, at which time 80% of the transects are at half bankfull flow elevations. However, average number of days of flows at 6,000 and 7,000 also increases by 6% and 12%, at which level 20 to 35% of all transects are at half bankfull flows, indicating that finer bed materials are mobilized in many areas and gravel embededness is reduced.

Table 13. Percentage of study transects used by Pitlick et al. (1999) at which half bankfull and bankfull flows are attained at a given river flow and the average number of days (and % difference) each flow is met or exceeded within a given year under baseline flows and the proposed action.

	Pitlick transects		Duration of flow		
Flow (cfs)	% at half bankfull	% at bankfull	Days, under baseline	Days, under proposed action	% Difference
6,000	19	0	28.0	29.6	+6
7,000	33	0	21.6	24.2	+12
8,000	46	2	16.5	17.6	+7
10,000	81	6	8.8	10.9	+24
14,000	100	46	3.1	3.5	+13

Flows in the range of 4,400 to 5,300 cfs also have the capacity to mobilize sand and finer sediments, which should function to keep spawning substrates relatively clean (Pitlick et al. 2007). Frequency of years flows reach near bankfull elevations (14,350 cfs) is 33% greater under the proposed action than baseline conditions, with nearly half of all transects subject to significant (bankfull) bed load motion. Additional information on an annual basis is included in Attachment 8.3.

The increase in frequency and duration of initial and significant motion (half- and bankfull flows) under the proposed action would help maintain the interstitial spaces in gravel and cobble bars that provide spawning habitat, habitat for larval fish immediately after hatching, and for macroinvertebrates which are important for the food web of the endangered fish. Increases in significant motion conditions shift cobble and gravel bars, scour vegetation, and help maintain side channels which overall help maintain or improve channel complexity of benefit to the fish.

Flow regimes under the proposed action would result in increased interannual variability. In particular, during moderately dry years, spring releases would be made in proportion to inflow at Blue Mesa (381,000 to 516,000 af), which adds more certainty that the Gunnison River at Whitewater would vary between 2,600 to 8,070 cfs from one year to the next (Table 3). Similar proportionality would be seen during average wet years. In contrast, under baseline flows, such proportionality would be maintained only if excess water was available. Increased variability should support in-channel processes that help maintain habitat for the endangered fish, particularly during moderately dry years when half bankfull conditions could be attained at a greater percentage of river reaches than under baseline flows.

The potential relative difference in fine sediment movement when baseline flows and proposed action flows are compared can be seen in the differences in half and bankfull flows. More fine sediment would be mobilized under proposed action flows than under the baseline. Higher flows also have a disproportionate increase in sediment movement compared to lower flows. Thus, the net result of increased frequency of high flows would also include a greater active channel area under the proposed action.

The proposed action will meet the duration targets of the flow recommendations more frequently than baseline flows. Thus the proposed action more closely approximates recommendations for flow durations made by Pitlick et al. (1999; summarized in McAda 2003). The frequencies for which the two alternatives meet the half and bankfull maintenance and improvement flows is shown in Table 14. In most flow categories the proposed action consistently would provide more days at the described flows than the baseline flow. Thus the proposed action would more closely approximate recommendations.

Table 14. Frequency (% of recommended days for meeting or exceeding flow level) at which baseline flows and proposed action flows meet flow recommendations for half and bankfull flows for channel maintenance and improvement. Higher frequencies under the proposed action are highlighted in green.

	Baseline flows				Proposed action			
	Maintenance flows		Improvement flows		Maintenance flows		Improvement flows	
Category	% 1/2 bankfull	% bankfull	% 1/2 bankfull	% bankfull	% 1/2 bankfull	% bankfull	% 1/2 bankfull	% bankfull
Dry	na	na	Na	na	na	na	na	na
Mod. Dry	na	Na	0%	na	na	na	0	na
Avg. dry	126%	Na	84%	na	130%	na	87%	na
Avg wet.	50%	0%	40%	0%	100%	0	70%	0
Mod wet	84%	41%	56%	20%	91%	52%	60%	26
wet	109%	170%	66%	108%	112%	166%	67%	100

Due to operational limitations including flood control, extremely high flows (> 15,000 cfs) would not be significantly increased by the proposed action and thus flows that significantly modify channel conditions and create new habitat would not increase. These flows would probably occur in the future due to extreme hydrologic conditions or forecast errors but would not differ significantly from baseline conditions.

Floodplain and backwater habitat would be improved under the proposed action. Overall, inundation of floodplains tends to increase significantly between 5,000 cfs and 14,000 cfs, and frequency and duration of spring peak flows in this range are greater under the proposed action than under baseline flow conditions (Table 15). At 5,000-6,000 cfs small floodplain wetlands begin to be inundated in the area immediately downstream of Delta (Johnson Boys' Slough, others), and the Craig gravel pit pond near Whitewater connects to the main channel Gunnison River (Reclamation 2006b). Flooded acreage at the Escalante State Wildlife Area increases with Gunnison River flows such that 80, 140 and 200 acres become inundated at 8,000, 10,000 and 14,000 cfs, respectively (Valdez and Nelson 2006; Burdick and Irving 1995). Wetlands near Confluence Park at Delta flood at about 9,000 to 10,000 cfs. Additional information on an annual basis is found in Attachment 8.3.

Table 15. Floodplain flows-Baseline and Proposed Action for period of study.

	Days >5,000 cfs (Craig, Johnson Boys' Slough)		Days > 8,000 cfs (Escalante 80 acs)		Days >10,000 cfs (Escalante 100 acs, Confluence Park)		Days > 14,000 cfs (Escalante 200 acs)	
	Baseline	Action	Baseline	Action	Baseline	Action	Baseline	Action
Avg. days/yr	35.4	36.3	16.5	17.6	8.8	10.9	3.1	3.5
% of yrs	68	87	52	61	35	48	19	26

In most instances, the proposed action would assure flows to operate the Redlands Fish Ladder from April through September and the Redlands Fish Screen as needed. Migration flows of 300 cfs are recommended downstream from Redlands. Due to shifts in water release volumes toward the spring peak period, the proposed action would result in an average of 32.2 days annually below that flow level compared to 22.3 days under the baseline during April-September. Flows less than 100 cfs would increase by an average of 1.2 days annually during the same period under the proposed action (See Attachment 10).

Changes in the mainstem of the Colorado River have not been analyzed in detail for this assessment. In general spring flows would be increased in magnitude and/or duration downstream from the Gunnison confluence. The greatest increase would be seen in moderately wet and moderately dry years, during which over 1,500-2,000 cfs would be added to the flow of the Colorado River. About 2,000 cfs and 1,000 cfs would be added in average dry and average wet years. Dry and wet year additions would generally be negligible. In any case, benefits to the Colorado River due to increased flows from the Gunnison River would probably be maximized during years in which coordinated reservoir operations in the upper Colorado River basin are implemented. Since 2000, water – from releases from upstream Colorado River reservoirs, coordinated reservoir operations, and irrigation efficiency improvements -- averaging 48,000 af per year, has proved endangered fish habitat (Recovery Program 2008). Attachment 9 summarizes peak and average monthly flow changes for the study period below the Gunnison confluence and information is summarized in Table 16.

Table 16. Approximate average contribution of Gunnison River (cfs) to Colorado River during May spring peak during study period.

	Baseline Conditions	Proposed Action
Dry Year	2,072	2,120
Moderately Dry Year	4,229	6,864
Average Dry Year	7,807	10,445
Average Wet Year	11,048	13,028
Moderately Wet Year	12,354	15,070
Wet Year	19,052	19,053

This PBA assumes that similar beneficial effects of the proposed action on the Gunnison River ecosystem and endangered fish will be accrued to some extent in the Colorado River ecosystem. This assumption should be considered an uncertainty that should be evaluated by the Recovery Program.

Reclamation (Boyer 2004) developed a model to depict reservoir release water temperatures under the Flow Recommendations. This model showed that overall, release water temperatures would be similar under baseline and proposed action conditions. In years with increased spring flows, warming of the main channel of the Gunnison River would be delayed. If peak flows remain at or above 3,000 cfs during June, favorable Colorado pikeminnow spawning temperatures (≥18 °C) would occur in the Whitewater area but not likely in the Delta area (Figure 7). Favorable temperatures would occur in both areas during July at flows of about 2,000 to 3,000, however. The trade-off between high flows for channel maintenance and spawning temperature regime in the Gunnison River is thus an uncertainty that may need to be evaluated by the Recovery Program. The temperature of the Colorado River is not expected to change significantly in relation to the proposed action (McAda 2003).

There will be effects on water quality. The Aspinall Unit has tended to improve water quality conditions in critical habitat by reducing extremely low flow months when pollutants are concentrated. From August thru March, the Unit generally has more than doubled pre-Aspinall Unit flows. At lower flows, seen in some months under the proposed action, the dilution effects of Aspinall releases are reduced. However, base flows should be maintained adequately to provide dilution, and provision of base flows will reduce periods of extremely low flows. Operations will continue to eliminate periods of extreme low flows seen prior to construction of the Unit. Table 17 shows modeled information on average monthly flows at the Whitewater gage under the proposed action and Table 18 summarizes a comparison of average monthly flows for the baseline and proposed action. From a cumulative impact standpoint, ongoing projects in the basin to reduce salinity and selenium loading are expected to continue and this should help maintain or improve water quality

The proposed action will affect selenium levels in the Gunnison River. Under the Flow Recommendations, higher May and June flows will tend to increase dilution of pollutants in the river while lower flows in other months will tend to increase concentrations of pollutants. Increasing releases to meet base flows will tend to increase dilution of pollutants in moderately dry periods and thus maximum selenium levels should be reduced. Table 19 summarizes projected effects of the proposed action compared to baseline conditions and Table 20 compares baseline to proposed action with respect to number of days per year the state standard for selenium is exceeded at Whitewater. Figure 8 displays baseline and proposed action for average and maximum monthly selenium levels. More detailed information is found in Attachment 6.

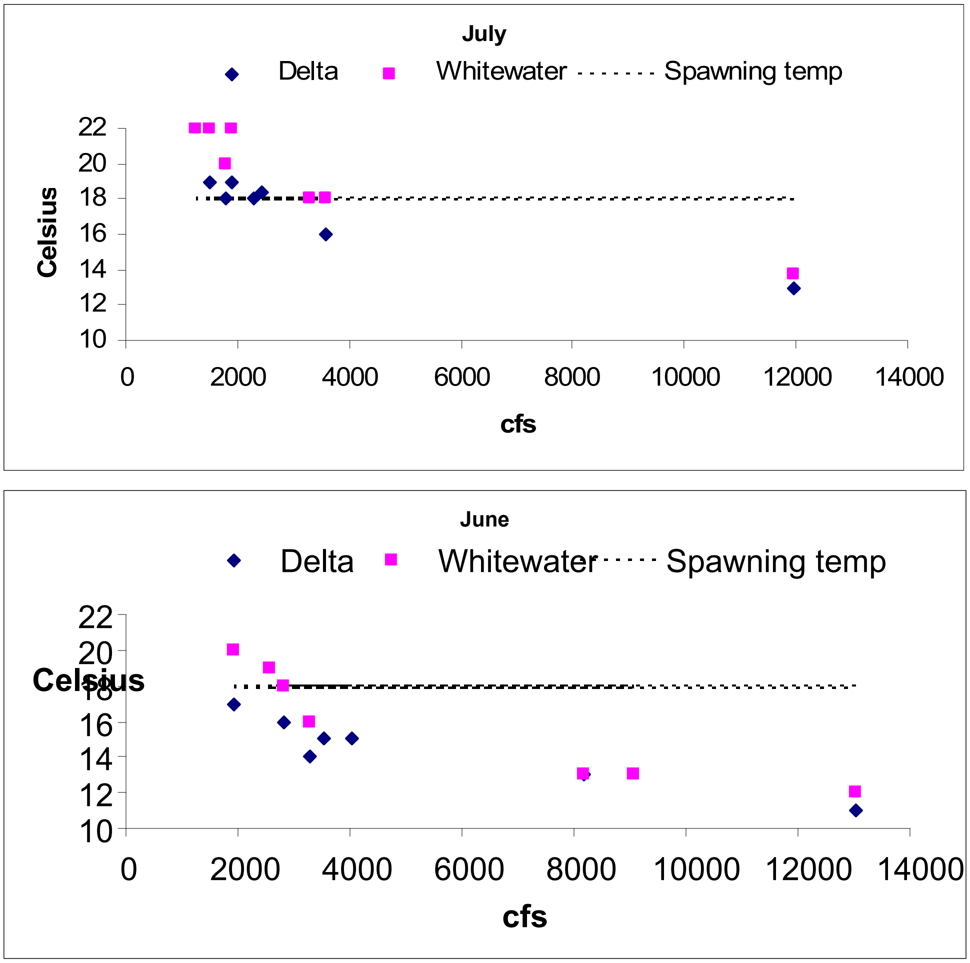


Figure 7. Gunnison River temperatures at Delta and Whitewater during June and July in relation to spawning temperature threshold for Colorado pikeminnow. Data were collected during 1992-2000 (McAda 2003).

6.4 Other Effects

The proposed action includes continuation of existing water uses and implementation of the Recovery Program and conservation measures. Existing water uses are included in the baseline and effects discussed include their continued operation. The continuation of the Recovery Program will support habitat restoration, monitoring, fish passage and screening, stocking, and better control of non-native fish. All of these actions are anticipated to have a positive effect on endangered fish populations.

Table 17. River flows (average monthly cfs), Gunnison River at Whitewater, for proposed action.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Peak daily mean
1975	1023	1022	1065	2422	6586	6328	3231	1929	1939	1866	1538	1489	12296
1976	1139	1189	1082	1620	5183	2293	1292	1025	1243	1395	905	807	8386
1977	789	767	757	785	846	879	939	794	795	902	873	778	1194
1978	764	748	858	3130	7000	7181	1696	1054	1162	1034	1098	1110	11364
1979	1046	2652	1906	4091	8976	9062	3043	1486	1207	1239	1163	1038	16261
1980	1033	2256	1576	3537	10244	7433	2319	1471	1286	1105	1190	1328	16326
1981	964	786	852	1304	1539	1423	1057	925	1179	1455	1082	826	3771
1982	1009	1144	1092	3277	7459	5157	2276	1938	2650	2604	2370	2299	11023
1983	1347	1277	1782	2797	8597	14045	7637	3031	2204	2445	2238	2531	17306
1984	2845	2629	2578	4918	13735	13699	6720	2774	2500	2997	2953	3179	19053
1985	2793	2241	2012	6587	10988	9986	2993	1608	2295	2680	2508	2600	15503
1986	2418	1655	3793	5421	8624	8032	3596	1947	2731	3335	3186	3250	13727
1987	1976	1795	2006	5171	6982	5710	1986	2032	2319	1809	1527	1516	10191
1988	1083	1196	1165	2267	2667	1849	1361	1046	1258	1030	901	818	5814
1989	851	1097	1614	2554	2508	1535	1331	1058	1117	1140	969	891	5243
1990	789	750	799	1006	1640	1584	1166	1014	1146	1352	962	883	2566
1991	813	781	864	1845	5278	4097	1904	1599	1994	1880	1630	1733	8593
1992	1124	1033	1138	3215	4130	2746	2073	1550	1631	1830	1565	1229	8583
1993	1050	1205	2843	4163	12387	10535	3747	2207	2345	2630	2215	1937	21040
1994	1328	1215	1489	2153	4503	2229	1550	1131	1409	1639	1428	1351	7755
1995	1044	963	2611	3348	9386	13708	12559	3024	2691	2767	2804	2729	19125
1996	1663	2156	2752	3485	7097	3507	1835	1342	1862	1781	1781	1856	12412
1997	2687	2716	2745	4364	9213	8632	3041	2405	3223	3177	2812	2716	14530
1998	1575	1461	2134	3578	7018	3129	2293	1519	1875	2038	1829	1718	9158
1999	1080	1085	1362	1374	4454	4381	2392	2576	2710	2352	2094	2043	7783
2000	1380	1393	1537	2719	3837	2190	1329	1066	1286	1417	1128	898	7840
2001	808	772	923	1487	4292	1711	1800	1323	1617	1496	1181	1112	7439
2002	969	823	840	1042	917	876	892	844	1094	1153	882	765	1170
2003	752	757	801	1181	3457	1825	1046	1060	1225	1020	858	770	7033
2004	779	765	1115	2038	2868	1313	1036	1060	1321	1304	980	889	5207
2005	943	898	1002	3958	7113	4503	2173	1435	1654	1923	1499	1186	11372
Mean study period	1286	1330	1584	2930	6114	5212	2655	1589	1773	1832	1618	1557	
Mean below average years	1017	1006	1175	1924	3573	2176	1494	1244	1448	1463	1212	1112	
Mean above average years	1576	1690	2041	4045	8959	8501	3924	1979	2138	2226	2059	2051	

Table 18. River flows (average monthly cfs), Gunnison River at Whitewater, for proposed action and baseline for study period.

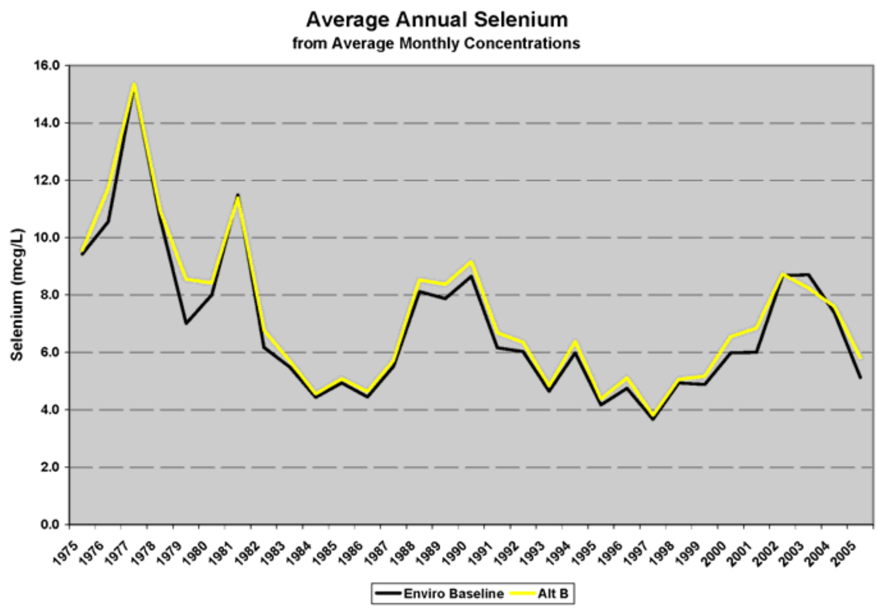
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline	1377	1408	1711	3122	5718	4993	2820	1641	1862	1895	1697	1650
Proposed Action	1286	1330	1584	2930	6114	5212	2655	1589	1773	1832	1618	1557

Table 19 Estimated selenium concentrations (mcg/L) at Whitewater gage under Baseline and under Proposed Action (proposed action shown in bold)

	Average annual concentration	Maximum monthly concentration	Minimum monthly concentration
1975	9.5 **9.5**	16.8 **14.1**	3.6 **4.2**
1976	10.7 **11.7**	16.0 **17.3**	4.8 **4.1**
1977	15.4 **15.4**	18.9 **19.1**	12.0 **12.5**
1978	10.7 **10.9**	17.9 **15.5**	3.3 **3.3**
1979	7.0 **8.5**	10.4 **13.1**	2.6 **2.8**
1980	8.0 **8.4**	15.1 **14.3**	2.4 **2.4**
1981	11.5 **11.4**	17.2 **14.2**	7.4 **7.7**
1982	6.3 **6.8**	9.9 **10.9**	2.7 **2.7**
1983	5.5 **5.7**	7.9 **8.5**	2.1 **2.1**
1984	4.4 **4.5**	6.6 **6.8**	1.9 **1.9**
1985	4.9 **5.1**	8.3 **8.3**	2.0 **2.0**
1986	4.4 **4.6**	6.8 **7.1**	2.2 **2.2**
1987	5.5 **5.7**	8.1 **8.5**	2.4 **2.4**
1988	8.2 **8.5**	11.7 **12.2**	4.2 **4.4**
1989	7.9 **8.4**	11.0 **11.4**	3.9 **4.0**
1990	8.8 **9.2**	11.2 **11.2**	5.2 **5.4**
1991	6.3 **6.7**	9.3 **10.3**	2.8 **2.8**
1992	6.0 **6.3**	7.8 **8.2**	3.0 **3.0**
1993	4.7 **4.8**	8.3 **8.2**	1.6 **1.7**
1994	6.0 **6.4**	8.4 **9.1**	3.1 **2.9**
1995	4.2 **4.4**	7.7 **8.0**	1.6 **1.6**
1996	4.7 **5.1**	6.9 **7.8**	2.2 **2.1**
1997	3.7 **3.8**	5.1 **5.3**	1.8 **1.8**
1998	4.9 **5.1**	6.8 **7.0**	1.9 **2.0**
1999	4.9 **5.2**	7.2 **7.5**	2.8 **2.7**
2000	6.0 **6.5**	8.5 **9.5**	3.2 **3.1**
2001	6.1 **6.8**	7.7 **9.2**	3.1 **2.7**
2002	8.7 **8.7**	10.6 **10.7**	6.**0** **6.4**
2003	8.6 **8.2**	11.7 **10.8**	3.5 **3.5**
2004	7.4 **7.6**	10.0 **9.7**	3.6 **3.4**
2005	5.3 **5.8**	7.8 **8.1**	1.8 **2.0**

Table 20. Number of days selenium concentration exceeds 4.6 ppb at Whitewater gage.

Year	Baseline	Proposed action
1975	311	325
1976	356	346
1977	365	365
1978	280	294
1979	275	276
1980	286	290
1981	363	363
1982	281	291
1983	254	256
1984	194	202
1985	233	257
1986	205	219
1987	259	261
1988	327	330
1989	320	316
1990	353	356
1991	289	295
1992	283	287
1993	225	225
1994	283	296
1995	169	176
1996	212	218
1997	68	106
1998	242	244
1999	242	263
2000	284	287
2001	301	319
2002	365	365
2003	326	327
2004	300	303
2005	229	266
Average	273.5	281.4



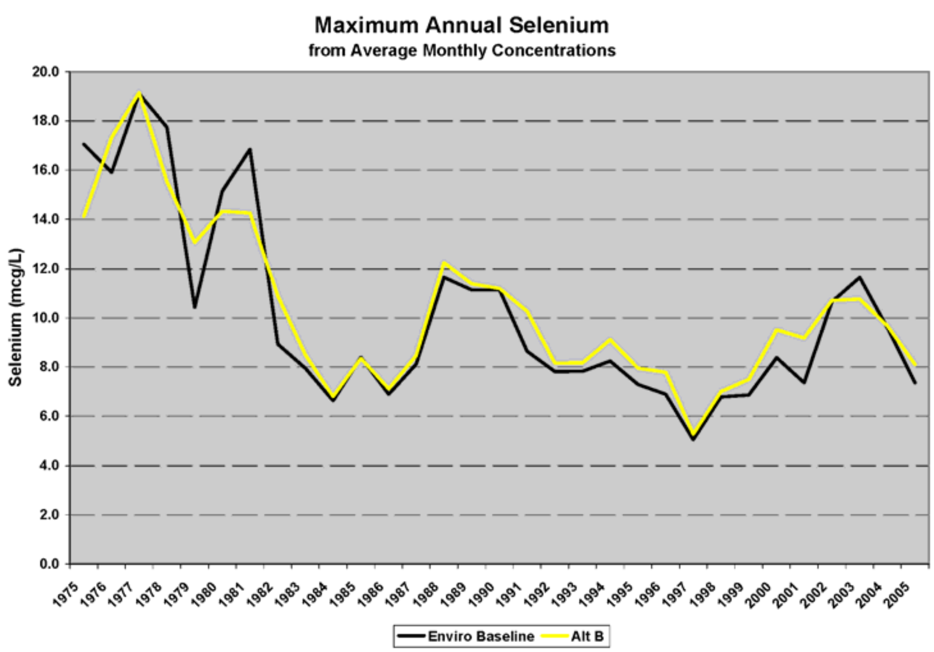


Figure 8. Selenium concentrations under baseline and proposed action, Whitewater gage.

6.5 Species Response to Proposed Action

As indicated in this assessment, there are a number of factors affecting the recovery of the endangered fish in the Gunnison River including reductions in habitat, competition with non-native fish, channelization, potential water quality concerns, and others. The proposed action does not resolve all of these factors but should improve conditions to increase recruitment and adult survival of the Colorado pikeminnow and razorback sucker in both the Gunnison and Colorado rivers and possibly the humpback in the Colorado River in conjunction with other Recovery Program actions. Response of the bonytail is unknown although the more natural hydrograph may have future benefits if populations are established.

In general, benefits of the proposed action include increased frequency and magnitude of relatively high spring flows to maintain channel conditions, spawning habitat, and channel complexity in critical habitat. The proposed flow regime should more closely resemble a natural flow regime when compared to baseline in that spring peaks would be greater in frequency, magnitude and duration, and that flows will vary among years in relation to snow pack and runoff. In addition to continuation of Recovery Program activities, the proposed action will provide benefits to the endangered fish and their habitat.

Species-specific effects of the proposed action are discussed below.

6.5.1 Colorado pikeminnow

6.5.1.1 Spawning

In all hydrologic categories, rising and falling hydrographs associated with the spring runoff from the North Fork and releases from the Aspinall Unit will provide environmental cues for Colorado pikeminnow spawning activity. Increased magnitude and duration of spring peak flows in the Gunnison River will maintain and improve spawning substrate by flushing fine sediment from the interstices of gravel and cobble substrates, which will improve survival of eggs and larvae. During moderately dry years, especially, increased frequency of peak flows between 2,600 and 8,070 cfs will improve spawning habitat even if widespread channel maintenance doesn't take place. Flows in the range of 4,400 to 5,300 cfs are also beneficial because they have the capacity to mobilize sand and finer sediments, which should function to keep spawning substrates relatively clean (Pitlick et al. 2007). At higher flows (average dry through wet years), cleansing of gravel and cobble bars will be much more widespread and would maximize Colorado pikeminnow reproductive success. Enhanced river flows in the Colorado River should elicit a similar response there.

With increased frequency of high flows comes a greater probability of delayed warming of the Gunnison River. Since Colorado pikeminnow spawn on the descending limb of the hydrograph (ca. 15-30% of the peak or 1-4 weeks after the peak; McAda and Kaeding 1991; Trammell and Chart 1999a; Anderson 1999), they tend to spawn later (ca. early to mid-July) during moderately wet and wet years and earlier during drier years (June; Figure 3.9 in McAda 2003). This adaptation is also related to the onset of favorable spawning temperatures (18-22 °C), which also occur later during wet years. Whereas spawning activity and hatching success should not be impeded directly by delayed warming, the growing season for offspring in wetter years is consequently shorter than during dry years. The effect may be partially offset due to greater connectivity with warm floodplain rearing habitats during wet years. Regardless, the trade-off facing Colorado pikeminnow between stream bed maintenance and temperature regime in the Gunnison River is an uncertainty that may need to be evaluated by the Recovery Program.

6.5.1.2 Larval and young-of-year habitat

As spring flows recede to base levels during the summer and fall, side channels and sandbar scour channels cease to flow and become backwaters. These are warm and productive environments which are important rearing habitat for larval and young-of-year Colorado pikeminnow. Under the proposed action, widespread maintenance of side channel and backwater habitats will occur at the half bankfull flow (8,070 cfs) in average dry to wet years, respectively. These flows would occur more frequently and with greater magnitude than those under baseline flows, helping to minimize vegetation encroachment, channel narrowing and vertical accretion of side-channel habitats. Cleansing of fine sediments from cobble bars and runs should also increase production of invertebrate prey items, on which juvenile stages of all endangered fish rely on for sustenance. Major changes in channel complexity will continue to depend on less frequent hydrologic events such as occurred in 1983, 1984 and 1993.

6.5.1.3 Adult habitat

The proposed action would help assure flows to operate the Redlands Fish Ladder from April through September and the Redlands Fish Screen. Due to shifts in water release volumes toward the spring peak period, the proposed action would result in an average of 32.2 days April through September below the migration minimum flow level compared to 22.3 days at baseline flows. Flows less than 100 cfs, which can significantly affect migration, would be increased by an average of 1.2 days under the proposed action (from 4.4 days to 3.2 days). Under both baseline and proposed action, most of the lower flows occur in very dry years, for example in 1977, 2002, and 2003 in the study period.

Higher and more frequent spring flows will provide more off-channel and floodplain habitat for feeding and resting of adult Colorado pikeminnow. These flows will also rework cobble bars, scour vegetation and help maintain overall channel complexity, the latter of which ensures a variety of habitats for Colorado pikeminnow feeding and resting throughout the course of a year. As mentioned above, also, flushing of fine sediments simultaneously prepares spawning habitat for Colorado pikeminnow and enhances primary and secondary productivity.

6.5.1.4 Non-native fish

Young-of-year Colorado pikeminnow share backwater rearing habitat with a host of non-native fish dominated by fathead minnow, sand shiner and red shiner. McAda and Ryel (1999) demonstrated that abundance of non-native cyprinid species during both summer (larvae) and autumn (juvenile and adults) was inversely correlated with magnitude of the previous spring peak flows, whereas relationship of young-of-year native fish to spring peak flows was either positive or statistically not significant. Thus, increased frequency and magnitude of spring peaks under the proposed action would disadvantage competitive and/or predatory non-native fish while not harming young-of-year native fish. Operation of the selective Redlands Fish Ladder would continue to prevent upstream migration of non-native fish into the Gunnison River.

6.5.1.5 Floodplain connectivity

In contrast with razorback sucker, Colorado pikeminnow reproduction is not as dependent on presence of floodplain wetlands for enhanced larval survival and growth. However, higher and more frequent spring flows will provide more off-channel and floodplain habitat for feeding and resting of adult Colorado pikeminnow prior to spawning, perhaps contributing to overall reproductive fitness.

6.5.1.6 Water quality

While flows in non-peak months will be reduced, base flows should remain adequate to continue to provide dilution flows and protect water quality (Tables 17-20). Other programs, such as salinity and selenium control programs, to protect/improve water quality will continue and will be supplemented by conservation measures associated with the proposed action and are expected to promote gradual improvements in water quality in the action area.

6.5.2 Razorback sucker

6.5.2.1 Spawning

Effects of the proposed action on razorback sucker spawning habitat would be very similar to those described for Colorado pikeminnow (Section 6.5.1.1). Since razorback sucker can spawn over a lower and wider range of temperatures (8-19 °C), delayed warming would probably not affect their larval growth and survival as much as it would Colorado pikeminnow.

6.5.2.2 Larval and young-of-year habitat

Effects of the proposed action on razorback sucker rearing habitat would be very similar to those described for Colorado pikeminnow (Section 6.5.1.2). Since razorback sucker rearing is thought to be more strongly associated off-channel floodplain wetlands, effects on those habitats are likely more important for razorbacks.

6.5.2.3 Adult Habitat

Effects of the proposed action on razorback sucker adult habitat would be very similar to those described for Colorado pikeminnow (Section 6.5.1.3). Like Colorado pikeminnow, adult razorback sucker utilize a variety of habitats throughout the course of the year and prefer complex river segments; thus, higher and more frequent spring peaks would work to maintain and perhaps improve channel complexity by mobilizing sediment, scouring vegetation and reducing accretion.

6.5.2.4 Non-native fish

Effects of the proposed action on non-native fish would be very similar to those described for Colorado pikeminnow (Section 6.5.1.4).

6.5.2.5 Floodplain connectivity

Razorback sucker spawning is timed to coincide with availability of inundated floodplains that provide warm, productive environments for larvae. Transport of larval fish into floodplains appears to be an important factor in determining recruitment of razorback sucker. In the Gunnison River, connection to important floodplain rearing habitats (Craig, Escalante, Confluence Park, and Johnson Boys' Slough) during the spring peak will be made under the proposed action more frequently and for longer durations than under baseline flows. The increase in duration of connection within a year is particularly important because a wider window of opportunity is open to drifting larvae for entrainment into productive rearing habitats. Additionally, the increased duration of flooding represents an opportunity for increased growth, since even short periods of inundation can provide the warm, food-rich habitat required for high survival of larvae (McAda 2003). This increased growth can be particularly important if size-dependent processes such as predation by small, gape-limited predators (e.g., red shiner) are important regulators of survival.

High flow connections (ca >14,000 cfs) to Escalante SWA are significant as they allow access to a 200 acre oxbow wetland, one of five tracts in the largest wetland complex in the Gunnison corridor. Both Colorado pikeminnow and razorback sucker are suspected to use these wetlands on a seasonal basis (Valdez and Nelson 2006). The connection to Craig is also significant as it has been recommended to receive stocking of hatchery-reared razorback sucker and could very likely entrain wild-spawned drifting larvae (Valdez and Nelson 2006).

6 .5.2.6 Water quality

Effects of the proposed action on water quality would be very similar to those described for Colorado pikeminnow (Section 6.5.1.6).

6.5.3 Humpback chub and bonytail

Benefits of the proposed action for humpback chub in the Colorado River would include most of what has been described for Colorado pikeminnow and razorback sucker, including:

- Spawning cues due to spring peak flows
- Maintenance of habitat complexity over a range of flows
- Maintenance of spawning gravel
- Creation and maintenance of backwaters
- Reduction of non-native fish due to higher flows

Attachment 9 summarizes expected changes in the Colorado River due to the proposed action.

Because of its extreme rarity, response of bonytail to the proposed action may be difficult to quantify. However, since all four endangered fish evolved together in the Colorado River ecosystem and the flow recommendations were based on common river restoration practices and habitat needs of the more common endangered species, bonytail should benefit from the proposed action as well.

6.6 Cumulative Effects

In the Service's regulations at 50 CFR 402.02, cumulative effects are defined as those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation. To the best of Reclamation's knowledge, there are no proposed, authorized or permitted water development projects or activities foreseen at the present time that have not been defined as part of the action. Therefore, despite Reclamation's finding that there may be adverse effects of listed species, state or private cumulative impacts are not projected.

6.7 Uncertainties and Take

Uncertainties discussed in the flow recommendations or related to the proposed action include:

- While relationships among initial motion, significant motion and streamflow are well defined, duration of flows necessary to accomplish habitat work is not completely known. Because flow duration recommendations were developed based on a wet period, the recommended durations require a large volume of water that may not always be available.

- Water availability may limit the ability of the Gunnison River to meet the Flow Recommendations under certain conditions.
- "…the duration of flows necessary to accomplish in-channel and out-of-channel habitat maintenance objectives is not known."[1]
- Because of timing and other differences in runoff patterns of the Colorado and Gunnison rivers, it is difficult to predict the effect of Gunnison River flow changes on the Colorado River.
- The trade-off facing Colorado pikeminnow between stream bed maintenance and temperature regime in the Gunnison River is an uncertainty that may need to be evaluated by the Recovery Program.
- The Recovery Program may need to evaluate the trade-off between high spring flows and base flows needed during the mid- to late summer to operate Redlands (and, to a lesser extent perhaps, maintain movement of sediment through the system).
- The effect of selenium and other water quality elements on the recovery of the endangered fish in the Gunnison and Colorado rivers and other basin rivers is not known and further monitoring by the Recovery Program may be needed.

For these reasons, the proposed action calls for using adaptive management (Section 2.2) to respond to new knowledge and using monitoring to evaluate the physical response of the habitat and biological response of the fish to the flow regimes.

Section 9 of the Endangered Species Act addresses "take". Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Take was considered in terms of continued diversions of water in critical habitat and in new and continued water depletions.

Incidental take associated with existing water diversions in Gunnison River critical habitat is difficult to assess but should not be significant. A previous biological opinion has addressed take for the Redlands Diversion, the only major diversion in critical habitat (Fish and Wildlife Service 2004). The other diversions in critical habitat are pumps or instream diversions for individual farms/orchards or small groups of users. These small diversions should pose little threat to adult and subadult fish. As fish recover and spawning increases in the Gunnison River, some loss of larval fish would be expected at these diversions; however because diversions generally divert well less than one percent of the river flow, losses should not be significant.

[1] Research under the Recovery Program is ongoing in the Gunnison River. Under one sediment-monitoring project the primary objective "…is to address key uncertainties in priority reaches of the Colorado, Gunnison, and Green Rivers relevant to the role of streamflows and sediment transport on the formation and maintenance of backwater habitats and spawning bars. A secondary objective is to collect the necessary sediment data to aide in the evaluation of Service flow recommendations for the Aspinall Unit and Flaming Gorge Reservoir." (Fish and Wildlife Service 2006).

Continued and new depletions associated with the proposed action are considered an adverse effect and are intended to be offset by new operations. New depletions can affect habitat and reproduction/recruitment; however, estimating the number of individuals of these species that would be taken as a result of water depletions is difficult to quantify.

The number of larvae that may be incidentally taken as a result of any of these factors is unknown. However, because of the potential for loss of individual listed species in fish screens and diversions, Reclamation requests an incidental take statement.

Another form of take might be associated with foregone growth potential due to higher frequency of high flows and potentially lower water temperatures and also perhaps the trade-off of moving water into the peak season at the expense of flows later in the year.

7.0 CONCLUSIONS

Based on the information and analysis of effects in this PBA, the following determinations were made for each of the listed species in the action area.

Clay-loving wild buckwheat	*Eriogonum pelinophilum*	no effect
Uinta Basin hookless cactus	*Sclerocactus glaucus*	no effect
Jones' cycladenia	*Cycladenia humilis var. jonesii*	no effect
Yellow-billed cuckoo	*Coccyzus americanus*	no effect
Mexican spotted owl	*Strix occidentalis lucida*	no effect
Southwestern willow flycatcher	*Empidonax traillii extimus*	no effect
California condor	*Gymnogyps californianus*	no effect
Colorado pikeminnow	*Ptychocheilus lucius*	may affect, likely to adversely affect
Razorback sucker	*Xyrauchen texanus*	may affect, likely to adversely affect
Humpback chub	*Gila lacypha*	may affect, likely to adversely affect
Bonytai	*Gila elegans*	may affect, likely to adversely affect
Black-footed ferret	*Mustela nigripes*	no effect
Canada lynx	*Lynx Canadensis*	no effect
Gunnison's prairie dog	*Cynomys gunnisoni*	no effect
Uncompahgre fritillary butterfly	*Boloria acrocnema*	no effect

When compared to the environmental baseline, the proposed action will have overall beneficial effects on the razorback sucker and Colorado pikeminnow and their critical habitat and may benefit the bonytail and humpback downstream in the Colorado River. The new operations of the Unit along with future Recovery Program efforts and conservation measures will improve designated critical habitat conditions for the fish as compared to baseline conditions. However, there is a potential for take under both the baseline and under the proposal. This potential take from entrainment in canals and depletions could result in the harm or kill of individual endangered fish in the Gunnison or Colorado rivers. Therefore, due to the potential for take, the finding is that the proposed action may affect, is likely to adversely affect endangered fish species.

Other species considered in this PBA should not be affected by the proposed action.

8.0 REFERENCES CITED

Anderson, R. M. 1999. Aspinall studies: annual assessment of Colorado pikeminnow larval production in the Gunnison and Colorado rivers, Colorado 1992-1996. Final Report to the Recovery Program for the Endangered Fishes of the Upper Colorado River, Project Number 43-B. Colorado Division of Wildlife, Grand Junction, CO.

Archer, D.L., L.R. Kaeding, B.D. Burdick, and C.W. McAda. 1985. A study of the endangered fishes of the Upper Colorado River, final report to U.S. Bureau of Reclamation. U.S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado.

Beason, Jason. 2008. RMBO finds yellow-billed cuckoos in western Colorado. Rocky Mountain Bird Observatory newsletter, October 2008. Brighton, CO.

Bestgen, K.R. 1990. Status review of the razorback sucker, *Xyrauchen texanus*. U.S. Bureau of Reclamation Upper Colorado Regional Office, Salt Lake City, Utah. 92 pages.

Bestgen, K.R., et al. 1997. Recruitment models for Colorado squawfish: tools for evaluating relative importance of natural and managed processes. Final report. Colorado State University Larval Fish Laboratory. 55 pages.

Bestgen, K.R., and L.W. Crist. 2000. Response of the Green River fish community to construction and re-regulation of Flaming Gorge Dam, 1962–1996. Final Report of Colorado State University Larval Fish Laboratory to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Bestgen, K.R., J.A. Hawkins, G.C. White, K.D. Christopherson, J.M. Hudson, M. Fuller, D.C. Kitcheyan, R. Brunson, P. Badame, G.B. Haines, J.A. Jackson, C. Walford, and T.A. Sorensen. 2006. Population status of Colorado pikeminnow in the Green River basin, Colorado. Transactions of the American Fisheries Society 136(5):1356-1380.

Beyers, D.W. and C. Sodergren. 1999. Assessment and prediction of effects of selenium exposure to larval razorback sucker. Final report to the Upper Colorado Endangered Fish Recovery Program. Contribution 107, Colorado State University Larval Fish Laboratory, Fort Collins.

Beyers, D.W. and C. Sodergren. 2001a. Evaluation of site-specific sensitivity to selenium exposure: larval razorback sucker versus flannelmouth sucker. Final report to the Upper Colorado Endangered Fish Recovery Program. Contribution 112, Colorado State University Larval Fish Laboratory, Fort Collins.

Beyers, D.W. and C. Sodergren. 2001b. Assessment of exposure of larval razorback sucker to selenium in natural waters and evaluation of laboratory-based predictions. Final report to the Upper Colorado Endangered Fish Recovery Program. Contribution 107, Colorado State University Larval Fish Laboratory, Fort Collins.

Boyer, J.M., and A. Cutler. 2004. Gunnison River/Aspinall Unit temperature study phase 2. Final report to the Final report to the Upper Colorado Endangered Fish Recovery Program. Bureau of Reclamation, Salt Lake City.

Bulkley, R.V. and R. Pimental. 1983. Temperature preference and avoidance by adult razorback suckers. Transactions of the American Fisheries Society 112(5):601-607.

Burdick, B.D. 1992. A plan to evaluate stocking to augment or restore razorback sucker in the upper Colorado River. Final report to the Upper Colorado Endangered Fish Recovery Program. U.S. Fish and Wildlife Service, Grand Junction, Colorado.

Burdick, Robert. 1995. Ichthyofaunal Studies of the Gunnison River, Colorado, 1992-1994. Final Report prepared for the Recovery Implementation Program. U.S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado. 58 pp.

_____. 2001. Five-year evaluation of fish passage at the Redlands Diversion Dam on the Gunnison River near Grand Junction, Colorado: 1996-2000. Final Report prepared for the Recovery Implementation Program, Project CAP-4b. U.S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado.

Burdick, B.D. 2003. Monitoring and evaluating various sizes of domestic-reared razorback sucker stocked in the upper Colorado and Gunnison rivers: 1995-2001. Final report to the Upper Colorado Endangered Fish Recovery Program. U.S. Fish and Wildlife Service, Grand Junction, Colorado.

Burdick, B.D. and McAda, C.W. 2007. Removal of smallmouth bass in the Upper Colorado River between Price-Stubb Dam near Palisade, Colorado, and Westwater, Utah. Annual Report to the Recovery Implementation Program. U.S. Fish and Wildlife Service, Grand Junction, Colorado.

Bureau of Reclamation. 2005. Operation of Flaming Gorge Dam, Final Environmental Impact Statement Technical Appendices. Salt Lake City, UT.

_____. 2006a. Evaluation of selenium remediation concepts for the Lower Gunnison and Lower Uncompahgre Rivers, Colorado. Prepared by the NIWQP and Reclamation's Technical Assistance to States Program in conjunction with the Gunnison Basin Selenium Task Force. Grand Junction, CO.

_____. 2006b. Physical evaluation of floodplain habitats restored/enhanced to benefit endangered fishes of the upper Colorado River basin. Annual Project Report C-6HYD. Colorado River Recovery Program.

_____. 2007. Final Environmental Impact Statement-Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead. Volume III pp.R-45-R-48. Salt Lake City, UT.

_____. 2008. Consumptive uses and losses report data. Salt Lake City, UT.

Butler, David L. 2000. Evaluation of water-quality data, Lower Gunnison River Basin and Colorado River downstream from the Aspinall Unit, Colorado. U.S.G.S. Administrative Report, Grand Junction, CO.

Cavalli, P. A. 1999. Fish community investigations in the lower Price River, 1996–1997. Final Report of Utah Division of Wildlife to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Chamberlain, T.K. 1946. Fishes, particularly the suckers, Catostomidae, of the Colorado River drainage and of the Arkansas River drainage, in relation to the Gunnison-Arkansas transmountain diversion. U.S. Fish and Wildlife Service, College Station, Texas.

Chart, T.E. and L. Lentsch. 1999. Flow effects on humpback chub (*Gila cypha*) in Westwater Canyon. Final report to the Upper Colorado Endangered Fish Recovery Program. Publication 99-36, Utah Division of Wildlife Resource.

Colorado Department of Natural Resources. 2006. Water supply and needs report for the Gunnison Basin. Prepared by CDM. Denver, CO.

Colorado Water Conservation Board and United States Department of Agriculture. 1962. Water and related land resources – Gunnison River Basin-Colorado. Salt Lake City, UT.

Converse, Y.K., C.P. Hawkins and R.A. Valdez. 1998. Habitat relationships of subadult humpback chub in the Colorado River through Grand Canyon: spatial variability and implications of flow regulation. Regulated Rivers Research and Management 14(3):267-284.

Day, K. S., K. D. Christopherson, and C. Crosby. 1999. An assessment of young-of-the-year Colorado pikeminnow (*Ptychocheilus lucius*) use of backwater habitats in the Green River, Utah. Report B in Flaming Gorge studies: assessment of Colorado pikeminnow nursery habitat in the Green River. Final Report of Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Day, K. S., K. D. Christopherson, and C. Crosby. 2000. Backwater use by young-of-year chub (*Gila* spp.) and Colorado pikeminnow (*Ptychocheilus lucius*) in Desolation and Gray Canyons of the Green River, Utah. Report B in Flaming Gorge studies reproduction and recruitment of *Gila* spp. and Colorado pikeminnow (*Ptychocheilus lucius*) in the middle Green River. Final Report of Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Dexter, C. 1998. River survey of west-central Colorado, for yellow-billed cuckoo and riparian weeds. Report prepared for the Bureau of Land Management. Cited in Fish and Wildlife Service (2005).

Fish and Wildlife Service. 1979. Biological Opinion for the Dallas Creek Project, Colorado. Memorandum from Acting Regional Director, Region 6 to Regional Director, Upper Colorado Region. Lakewood, Colorado.

_____. 1980. Biological Opinion for the Dolores Project, Colorado. Memorandum from Regional Director, Region 6 to Regional Director Upper Colorado Region. Lakewood, Colorado.

_____. 1993. Section 7 consultation, sufficient progress, and historic projects agreement and recovery action plan, Recovery Implementation Program for the endangered fish species in the Upper Colorado River Basin. Denver, Colorado.

_____.1994. Conceptual Management Plan for habitat enhancement in flooded bottomlands, Escalante State Wildlife Area, Gunnison River downstream of Delta, Colorado. Prepared for Recovery Implementation Program for Endangered Fishes in the Upper Colorado River Basin. Grand Junction, Colorado.

_____. 1999. Memorandum dated July 14, 1999: categorical exclusion for NEPA compliance on agreement for use of 60,000 acre-feet in the Upper Gunnison River Basin. Memorandum from Assistant Field Supervisor to Area Manager Western Colorado Area Office, Grand Junction, Colorado.

_____. 1999b. Final Programmatic Biological Opinion for Bureau of Reclamation's operations and depletions, other depletions, and funding and implementation of Recovery Program actions in the Upper Colorado River above the confluence with the Gunnison River. Region 6, Denver, Colorado.

_____. 2000. Section 7 Consultation, sufficient progress, and historic projects agreement and Recovery Action Plan, Recovery Implementation Program for the endangered fish species in the Upper Colorado River Basin (revised from 1993). Denver, Colorado.

_____. 2002. Bonytail (*Gila elegans*) Recovery Goals: amendment and supplement to the Bonytail Chub Recovery Plan. Mountain-Prairie Region (6), Denver, Colorado.

_____. 2002b. Final Biological Opinion for the water service contract with the Ragged Mountain Water Users Association and the North Fork Water Conservancy District, Paonia Project. Region 6, Denver, Colorado.

_____. 2002c. Colorado pikeminnow (*Ptychocheilus lucius*) Recovery Goals: amendment and supplement to the Colorado Pikeminnow Recovery Plan. Region 6, Denver, Colorado.

_____. 2002d. Razorback sucker (*Xyrauchen texanus*) Recovery Goals: amendment and supplement to the Razorback Sucker Recovery Plan. Region 6, Denver, Colorado.

_____. 2002e. Humpback chub (*Gila cypha*) Recovery Goals: amendment and supplement to the Humpback Chub Recover Plan. Region 6, Denver, Colorado.

_____. 2004. Final Biological Opinion for the Redlands Water and Power Company's Canal Fish Screen, Mesa County, Colorado. Region 6, Denver Colorado.

_____. 2005. Species assessment and listing priority assignment for Yellow-billed cuckoo. Region 1. Sacramento, California.

_____. 2005b. Annual report Upper Colorado River Recovery Program. Denver, CO.

_____. 2006. Annual report Upper Colorado River Recovery Program. Denver, CO.

_____. 2008. News Release: Gunnison's prairie dog populations in portions of Colorado and New Mexico warranted for listing under the Endangered Species Act. February 1, Lakewood, CO.

Gilpin, M. 1993. A population viability analysis of the Colorado squawfish in the upper Colorado River basin. U.S. Fish and Wildlife Service, Denver, Colorado.

Haines, G.B. and H.M. Tyus. 1990. Fish associations and environmental variables in age-0 Colorado squawfish habitats, Green River, Utah. Journal of Freshwater Ecology 5(4):427-435.

Hamilton, Steven J. 1999. Hypothesis of historical effects from selenium on endangered fish in the Colorado River Basin. In: Human and Ecological Risk Assessment: Vol. 5, No.6, pp. 1153-1180. U.S. Geological Survey, Yankton, South Dakota.

Hamilton, S.J., R.T. Muth, B. Waddell, and T.W. May. 2000. Hazard assessment of selenium and other trace elements in wild larval razorback sucker from the Green River, Utah. Ecotoxicology and Environmental Safety 45(2):132-47.

Hamman, R.L. 1981. Spawning and culture of Colorado squawfish in raceways. Progressive Fish Culturist 43(4):173-177.

Harvey, M.D., R.A. Mussetter, and E.J. Wick. 1993. A physical process-biological response model for spawning habitat formation for the endangered Colorado squawfish. Rivers 4(2):114-131.

Hawkins, J.A. 1992. Age and growth of Colorado squawfish from the Upper Colorado River Basin, 1978-1990. Master's Thesis. Colorado State University, Fort Collins. and Colorado Division of Wildlife to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Holden, P.B. 1977. Study of the habitat use and movement of the rare fishes in the Green River from Jensen to Green River, Utah, August and September, 1977. Final report. BIO/WEST, Inc., Logan, Utah (prepared for Western Energy and Land Use Team, Fort Collins, Colorado). 58 pages.

_____. 2000. Program evaluation report for the 7-year research period (1991-1997). San Juan River Basin Recovery Implementation Program, U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

Holden, P.B. and C.L. Stalnaker. 1975. Distribution and abundance of mainstream fishes of the middle and upper Colorado River Basins, 1967-1973. Transactions of the American Fisheries Society 104:217-231.

Holden, P.B., C. Richard, L. Crist, and J. Campbell. 1981. Aquatic biology studies for proposed Colorado-Ute Electrical Association power plant near Grand Junction, Colorado. BIOWEST, Inc., Logan, Utah. PR56-1. 66pp.

Hudson, J.M., and J.A. Jackson. 2003. Population estimates for humpback chub (*Gila cypha*) and roundtail chub (*Gila robusta*) in Westwater Canyon, Colorado River, Utah 1998-2000.

Hydrosphere Resource Consultants. 2002. Gunnison River/Aspinall Unit temperature study phase 1. Final report to the Final report to the Upper Colorado Endangered Fish Recovery Program.

Irving, D., and T. Modde. 2000. Home-range fidelity and use of historical habitat by adult Colorado squawfish (*Ptychocheilus lucius*) in the White River, Colorado and Utah. Western North American Naturalist 60:16–25.

Irving, D and B Burdick. 1995. Reconnaissance inventory and prioritization of existing and potential bottomlands in the upper Colorado River basin, 1993-1994. Final Report to the Recovery Program for the Endangered Fishes of the Upper Colorado River. U.S. Fish and Wildlife Service, Vernal, Utah and Grand Junction, Colorado.

Johnson, Donn M. and Richard G. Walsh. 1987. Economic benefits and costs of the fish stocking program at Blue Mesa Reservoir, Colorado. Colorado water Resources Research Institute, Colorado State University, Ft. Collins, CO.

Johnson, Brett M. and Marci L. Koski. 2005. Reservoir and food web dynamics at Blue Mesa Reservoir, Colorado, 1993-2002. Colorado State University Fisheries Ecology Laboratory, prepared for Bureau of Reclamation, Denver, CO.

Jordan, D.S. 1891. Report of explorations in Colorado and Utah during the summer of 1889, with an account of the fishes found in each of the river basins examined. U.S. Fish Comm. Bull. 9(1889):1-40.

Kaeding, L.R., B.D. Burdick, P.A. Schrader, and C.W. McAda. 1990. Temporal and spatial relations between the spawning of humpback chub and roundtail chub in the Upper Colorado River. Transactions of the American Fisheries Society 119:135-144.

Kidd, George. 1977. An investigation of endangered and threatened fish species in the upper Colorado River as related to Bureau of Reclamation projects. Final Report. Northwest Fisheries Research, Clifton, Colorado.

Kingery, H.E. (ed). 1998. Colorado breeding bird atlas. Colorado Bird Atlas Partnership and Colorado Division of Wildlife, Denver, Colorado.

Korte, N.E. 2000. Selenium poisoning of wildlife and western agriculture: cause and effect. Oak Ridge National Laboratory, Environmental Sciences Division, Oak Ridge, TN.

Kowalski, Dan. 2008. Personal communication. Aspinall operations meeting, August 2008.

Lamarra, Vincent. 1999. Longitudinal variation in the trophic structure of the Upper Colorado River. Final Report to the Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River, Project Number 48-Report B. Ecosystems Research Institute, Inc. Logan, UT.

Lentsch, L.D., R.T. Muth, P.D. Thompson, B.G. Hoskins and T.A. Crowl. 1996. Options for selective control of nonnative fishes in the upper Colorado River basin. Utah Division of Wildlife Resources, Salt Lake City.

Lyon, Peggy and Earl Williams. 1998. Natural Heritage biological survey of Delta County, Colorado. Colorado Natural Heritage Program, Ft. Collins, CO.177 pp.

Marsh, P.C. 1985. Effect of incubation temperature on survival of embryos of native Colorado River fishes. The Southwestern Naturalist 30(1):129-140.

Marsh, P. C., M. E. Douglas, W. L. Minckley, and R. J. Timmons. 1991. Rediscovery of Colorado squawfish, *Ptychocheilus lucius* (Cyprinidae) in Wyoming. Copeia 1991:1091–1092.

McAda, C.W. 1997. Mechanical removal of northern pike from the Gunnison River, 1995-1996. Final report to the Upper Colorado Endangered Fish Recovery Program. U.S. Fish and Wildlife Service, Grand Junction.

_____. 2002. Population size and structure of humpback chub *Gila cypha* in Black Rocks, 1998-2000. Final report to the Upper Colorado Endangered Fish Recovery Program. U.S. Fish and Wildlife Service, Grand Junction.

_____. 2003. Flow recommendations to benefit endangered fishes in the Colorado and Gunnison Rivers. Recovery Program Project Number 54, Final Report. Grand Junction CO.

_____. 2007. Population size and structure of humpback chub *Gila cypha* in Black Rocks, 2003-2004. Final report to the Upper Colorado Endangered Fish Recovery Program. U.S. Fish and Wildlife Service, Grand Junction.

McAda, C.W. and B.D. Burdick. 2006. Evaluation of stocked razorback sucker and Colorado pikeminnow in the Gunnison River. Annual report to the Colorado Endangered Fish Recovery Program. Available at http://www.fws.gov/mountain-prairie/crrip/arpts/2006/rsch/121b.pdf. Accessed 2/08.

_____. 2007. Evaluation of stocked razorback sucker and Colorado pikeminnow in the Gunnison River. Annual report to the Colorado Endangered Fish Recovery Program. Available at http://www.fws.gov/mountain-prairie/crrip/arpts/2007/rsch/121b.pdf. Accessed 2/08.

McAda, C.W. and K. Fenton. 1998. Relationship of fish habitat to river flow in the Gunnison River. Final report to the Final report to the Upper Colorado Endangered Fish Recovery Program. U.S. Fish and Wildlife Service, Grand Junction.

McAda, C.W. and L.R. Kaeding. 1991. Movements of adult Colorado pikeminnow during the spawning season in the upper Colorado River. Transactions of the American Fisheries Society 120:339-345.

_____. 1991. Movements of adult Colorado pikeminnow during the spawning season in the upper Colorado River. Transactions of the American Fisheries Society 120:339-345.

McAda, C.W. and R.J. Ryel. 1999. Distribution, relative abundance and environmental correlates for age-0 Colorado pikeminnow and sympatric fishes in the upper Colorado River. Final report to the Upper Colorado Endangered Fish Recovery Program. U.S. Fish and Wildlife Service, Grand Junction.

McAda, C.W. and R.S. Wydoski. 1980. The razorback sucker (*Xyrauchen texanus*), in the Upper Colorado River Basin, 1974-76. U.S. Fish and Wildlife Service Technical Paper No. 99. 15 pp.

McCarthy, M.S. and W.L. Minckley. 1987. Age estimation for razorback sucker (Pisces: catostomidae) from Lake Mohave, Arizona and Nevada. Journal of the Arizona-Nevada Academy of Science 21:87-97.

Minckley, W.L 1973. Fishes of Arizona. Arizona Fish Game Publication, Phoenix.

_____. 1991. Native fishes of the Grand Canyon region: an obituary? In: Colorado River Ecology and Dam Management, pp. 124-177. National Academy Press, Washington D.C.

Milhous, R. T. 1998. Modeling of instream flow needs: the link between sediment and aquatic habitat. (Cited in McAda, 2003). Regulated Rivers: Research and Management 14: 79-94.

Modde, T. 1996. Juvenile razorback sucker (*Xyrauchen texanus*) in a managed wetland adjacent to the Green River. Great Basin Naturalist 56: 375-376.

Modde, T., K.P. Burnham and E.J. Wick. 1996. Population status of the razorback sucker in the middle Green River. Conservation Biology 10:119-119.

Muth R. T. and D. E. Snyder. 1995. Diets of young Colorado squawfish and other small fish in backwaters of the Green River, Colorado and Utah. Great Basin Naturalist 55:95–104.

Muth, R. T. and T. P. Nesler. 1993. Associations among flow and temperature regimes and spawning periods and abundance of young of selected fishes, lower Yampa River, Colorado, 1980–1984. Final Report of Colorado State University Larval Fish Laboratory to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Muth, R. T., G. B. Haines, S. M. Meismer, E. J. Wick, T. E. Chart, D. E. Snyder, and J. M. Bundy. 1998. Reproduction and early life history of razorback sucker in the Green River Utah and Colorado, 1992-1996. Final Report to the Recovery Program for the Endangered Fishes of the Upper Colorado River, Project Number 34, Larval Fish Laboratory, Colorado State University, Ft. Collins, CO.

Muth, R.T., L.W. Crist, K.E. LaGory, J.W. Hayse, K.R. Bestgen, T.P. Ryan, J.K. Lyons, R.A. Valdez. 2000. Flow and temperature recommendations for endangered fishes in the Green River downstream of Flaming Gorge Dam. Upper Colorado River Endangered Fish Recovery Program Project FG-53, Denver, Colorado.

Nehring, R. Barry. 1988. Fish Flow Investigations. Colorado Division of Wildlife, Federal Aid in Fish and Wildlife Restoration, F-51-R, Progress Report, Ft. Collins, CO.

Nehring, R. Barry and R. Anderson. 1985. Fish Flow Investigations. Colorado Division of Wildlife, Federal Aid in Fish and Wildlife Restoration, F-51-R, Job No. 1, Progress Report, Ft. Collins, CO.

Nehring, R. Barry and D.D. Miller. 1987. The influence of spring discharge levels on rainbow trout and brown trout recruitment and survival, Black Canyon of the Gunnison River, Colorado, as determined by IFIM/PHABSIM models. Proceedings of the Western Association of Fish and Wildlife Agencies and the Western Division of the American Fisheries Society.

Osmundson, Douglas B. 1999. Longitudinal variation in fish community structure and water temperature in the Upper Colorado River: implications for Colorado Pikeminnow habitat suitability. Final Report to the Recovery Implementation Program for the Endangered Fishes of the Upper Colorado River, Project Number 48. Fish and Wildlife Service, Grand Junction, CO.

Osmundson, D.B., R.J. Ryel, V.L. Lamarra, and J. Pitlick. 2002. Flow-sediment-biota relations: implications for river regulation effects on native fish abundance. Ecological Applications 12(6), pp. 1719-1739.

Osmundson, D.B. and C.W. McAda. 2006. Verification of stocked razorback sucker reproduction in the Gunnison and upper Colorado rivers via annual collection of larvae. Annual report to the Final report to the Upper Colorado Endangered Fish Recovery Program. U.S. Fish and Wildlife Service, Grand Junction.

_____. 2006. Verification of stocked razorback sucker reproduction in the Gunnison and upper Colorado rivers via annual collection of larvae. Annual report to the Final report to the Upper Colorado Endangered Fish Recovery Program. U.S. Fish and Wildlife Service, Grand Junction.

Osmundson, D.B., P. Nelson, and D. Ryden. 1995. Relationships between flow and rare fish habitat in the 15-mile reach of the upper Colorado River. Final Report. U.S. Fish and Wildlife Service, 127 pp + 82 pp appendices.

Osmundson, D.B. and K.P. Burnham. 1998. Status and trends of the endangered Colorado squawfish in the Upper Colorado River. Transactions of the American Fisheries Society 127:957-970.

Osmundson, D.B., R.J. Ryel, M.E. Tucker, B.D. Burdick, W.R. Elmblad, and T.E. Chart. 1997. Dispersal patterns of sub-adult and adult Colorado squawfish in the upper Colorado River. Transactions of the American Fishery Society 127:943-956.

Osmundson, D.B. and L.R. Kaeding. 1989. Studies of Colorado squawfish and razorback sucker use of the "15-mile reach" of the upper Colorado River as part of conservation measures for the Green Mountain and Ruedi Reservoir water sales. Final Report. Colorado River Fishery Project, U.S. Fish and Wildlife Service, Grand Junction, Colorado. 85 pp.

_____. 1991. Recommendations for flows in the 15-mile reach during October-June for maintenance and enhancement of endangered fish populations in the Upper Colorado River. Final report to the Final report to the Upper Colorado Endangered Fish Recovery Program. U.S. Fish and Wildlife Service, Grand Junction.

Osmundson, D. B., R. J. Ryel, M. E. Tucker, B. D. Burdick, W. R. Elmblad, and T. E. Chart. 1998. Dispersal patterns of subadult and adult Colorado squawfish in the upper Colorado River. Transactions of the American Fisheries Society 127:943–956.

Osmundson, D.B. and L.R. Kaeding. 1991. Recommendations for flows in the 15-mile reach during October-June for maintenance and enhancement of endangered fish populations in the Upper Colorado River. Final report to the Final report to the Upper Colorado Endangered Fish Recovery Program. U.S. Fish and Wildlife Service, Grand Junction.

Osmundson, D. B., R. J. Ryel, M. E. Tucker, B. D. Burdick, W. R. Elmblad, and T. E. Chart. 1998. Dispersal patterns of subadult and adult Colorado squawfish in the upper Colorado River. Transactions of the American Fisheries Society 127:943–956.

Pitlick, J. 2007. Channel monitoring to evaluate geomorphic changes on the main stem of the Colorado River. Final report to the Final report to the Upper Colorado Endangered Fish Recovery Program. University of Colorado, Boulder.

Pitlick, J., M. Van Steeter, B. Barkett, R. Cress, and M. Franseen. 1999. Geomorphology and hydrology of the Colorado and Gunnison Rivers and implications for habitats used by endangered fishes. Final Report to the Recovery Program for the Endangered Fishes of the Upper Colorado River, Project Number 44. Department of Geography, University of Colorado, Boulder, Colorado.

Pitlick, J. and R. Cress. 2000. Longitudinal trends in channel characteristics of the upper Colorado River and implications for food-web dynamics. Final Report to the Recovery Program for the Endangered Fishes of the Upper Colorado River, Project Number 48. Department of Geography, University of Colorado, Boulder, Colorado.

Poff, N.L., J.D. Allen, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richeter, R.E. Sparks, and J.C. Stromberg. 1997. The natural flow regime: a paradigm for river conservation and restoration. Bioscience 47:769-784.

Quartarone, F. 1993. Historical accounts of upper basin endangered fish. Colorado Division of Wildlife. Denver, Colorado. 66pp.

Ray, A.J., J Barsugli, and K. Avery. 2008. Climate change in Colorado. Prepared for Colorado Water Conservation Board by Western Water Assessment. Boulder, CO.

Recovery Program. 2006a. Upper Colorado River Endangered Fish Recovery Program coordinated reservoir operations implementation plan. Available at http://www.fws.gov/mountain-prairie/crrip/doc/finalCROSFeb272006.pdf. Accessed 2/08.

_____. 2006b. Evaluation of population estimates for Colorado pikeminnow and humpback chub in the upper Colorado River basin. Upper Colorado River Endangered Fish Recovery Program, Lakewood. Available at http://www.fws.gov/mountain-prairie/crrip/doc/POPEST8-31-06.pdf. Accessed 2/08.

_____. 2007. Upper Colorado River Endangered Fish Recovery Program/San Juan River Basin Recovery Implementation Program-program highlights. Denver CO.

_____. 2008. Upper Colorado River Endangered Fish Recovery Program/San Juan River Basin Recovery Implementation Program-program highlights. Denver CO.

Seglund, Amy E, A. Ernst, and D. O'Neill. 2005. Gunnison's prairie dog conservation assessment. Western Association of Fish and Wildlife Agencies. Laramie, Wyoming.

Stanford, J.A. 1994. Instream flows to assist the recovery of endangered fishes of the upper Colorado River basin. U.S. Department of Interior, National Biological Survey, Biological Report 24.

Stanford, J. and J. Ward. 1983. The effects of mainstream dams on physiochemistry of the Gunnison River, Colorado. Proceedings of the 1981 symposium on the aquatic resources management of the Colorado River ecosystem. Edited by V. Adams and V. Lamarra. Ann Arbor Science Publishers, Ann Arbor, Michigan.

Stanford, J.A., J.V. Ward, W.J. Liss, C.A. Frissell, R.N. Williams, J.A. Lichatowich, and C.C. Coutant. 1996. A general protocol for restoration of regulated rivers. Regulated Rivers: Research and Management 12:391-413.

Taba, S.S., J.R. Murphey, and H.H. Frost. 1965. Notes on the fishes of the Colorado River near Moab, Utah. Utah Academy Proceedings 42:280-283 pp.

Thompson, J.M., E.P. Bergersen, C.A. Carlson, and L.R. Kaeding. 1991. Role of size, conditions, and lipid content in the overwinter survival of age-0 Colorado squawfish. Transactions of the American Fisheries Society 120:346-351.

Trammell, M., and T. Chart. 1999a. Aspinall studies: annual assessment of Colorado pikeminnow larval production in the Colorado River, Utah 1992-1996. Final report to the Final report to the Upper Colorado Endangered Fish Recovery Program. Publication 99-15, Utah Division of Wildlife Resources, Salt Lake City.

_____. 1999b. Aspinall studies: evaluation of nursery habitat availability and Colorado pikeminnow young-of-year habitat use in the Colorado River, Utah 1992-1996. Final report to the Upper Colorado Endangered Fish Recovery Program. Publication 99-18, Utah Division of Wildlife Resources, Salt Lake City.
Tyus, H.M. 1985. Homing behavior noted for Colorado squawfish. Copeia (1):213-215.

_____. 1987. Distribution, reproduction, and habitat use of the razorback sucker in the Green River, Utah, 1979-1986. Transactions of the American Fisheries Society 116(1):111-116.

_____. 1990. Potamodromy and reproduction of Colorado squawfish, *Ptychocheilus lucius*. Transactions of the American Fisheries Society 119(6):1035-1047.

_____. 1991. Movements and habitat use of young Colorado squawfish in the Green River, Utah. Journal of Freshwater Ecology 6(1):43-51.

_____. 1998. Early records of the endangered fish *Gila cypha* Miller from the Yampa River of Colorado with notes on its decline. Copeia 1:190-193.

Tyus, H.M. and C.W. McAda. 1984. Migration, movements and habitat preferences of Colorado squawfish, *Ptychocheilus lucius*, in the Green, White and Yampa Rivers, Colorado and Utah. Southwestern Naturalist 29(3):289-299.

Tyus, H.M. and C.A. Karp. 1989. Habitat use and streamflow needs of rare and endangered fishes, Yampa River, Colorado. U.S. Fish and Wildlife Service, Biological Report 89(14):27.

Tyus, H.M. and G.B. Haines. 1991. Distribution, habitat use, and growth of age-0 Colorado squawfish in the Green River basin, Colorado and Utah. Transactions of the American Fisheries Society 120(1):79-89.

Tyus, H.M. and C.A. Karp. 1990. Spawning and movements of razorback sucker *Xyrauchen texanus* (Abbott) in the Green River basin of Colorado and Utah. Southwestern Naturalist 35(4):427-433.

Tyus, H.M., B.D. Burdick, R.A. Valdez, C.M. Haynes, T.A. Lytle, and C.R. Berry. 1982. Fishes of the Upper Colorado River Basin: Distribution, abundance, and status. Pages 12-70 *in* W.H. Miller, H.M. Tyus, and C.A. Carlson, eds. Fishes of the Upper Colorado River System: Present and future. Western Division, American Fisheries Society, Bethesda, MD.

Tyus, Harold M. and James F. Saunders III. 2001. An evaluation of the role of tributary streams for recovery of endangered fishes in the Upper Colorado River Basin, with recommendations for future recovery actions. Upper Colorado Endangered Fish Recovery Program, Project no. 101. University of Colorado, Boulder, CO.

Valdez, R.A. and P. Nelson. 2006. Upper Colorado River Subbasin Floodplain Management Plan. Upper Colorado Endangered Fish Recovery Program, Lakewood.

Valdez, R.A. and G.C. Clemmer. 1982. Life history and prospects for recovery of the humpback and bonytail chub. Pages 109-119 *in* W.H. Miller, H.M. Tyus, and C.A. Carlson, eds. Fishes of the upper Colorado River system: Present and future. Western Division, American Fisheries Society, Bethesda, MD.

Valdez, R.A., P.B. Holden, T.B. Hardy and R.J. Ryel. 1987. Habitat suitability index curves for endangered fishes of the upper Colorado River basin. Final report. U.S. Fish and Wildlife Service HSI Curve Development Project, BIO/WEST, Logan, Utah. No. 14-16-0006-86-055.

Valdez, R.A. and W. Masslich. 1989. Winter habitat study of endangered fish-Green River: Wintertime movement and habitat of adult Colorado squawfish and razorback suckers. Report to U.S. Bureau of Reclamation, Salt Lake City, Utah. BIO/WEST Report No. 136-2, Logan, UT. 178 pp.

Valdez, R.A., P.G. Mangan, M. McInerny, and R.P. Smith. 1982. Tributary report: fishery investigations of the Gunnison and Dolores rivers. Pages 321-365 in W.H. Miller et al., editors. Colorado River Fishery Project, Final Report; Part Two, field studies. U.S. Fish and Wildlife Service and Bureau of Reclamation. Salt Lake City, Utah.

Valdez, R.A., P. Mangan, R. Smith, and B. Nilson. 1982b. Upper Colorado River investigations (Rifle, Colorado to Lake Powell, Utah). Pages 101-279 *in* W.H. Miller et al., editors. Colorado River Fishery Project Final Report; Part Two, Field Studies. U.S. Fish and Wildlife Service and Bureau of Reclamation, Salt Lake City, Utah.

Valdez, R.A., B.R. Cowdell, and L.D. Lentsch. 1999. Overwinter survival of age-0 Colorado pikeminnow in the Green River, Utah, 1987–1995. Final Report to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

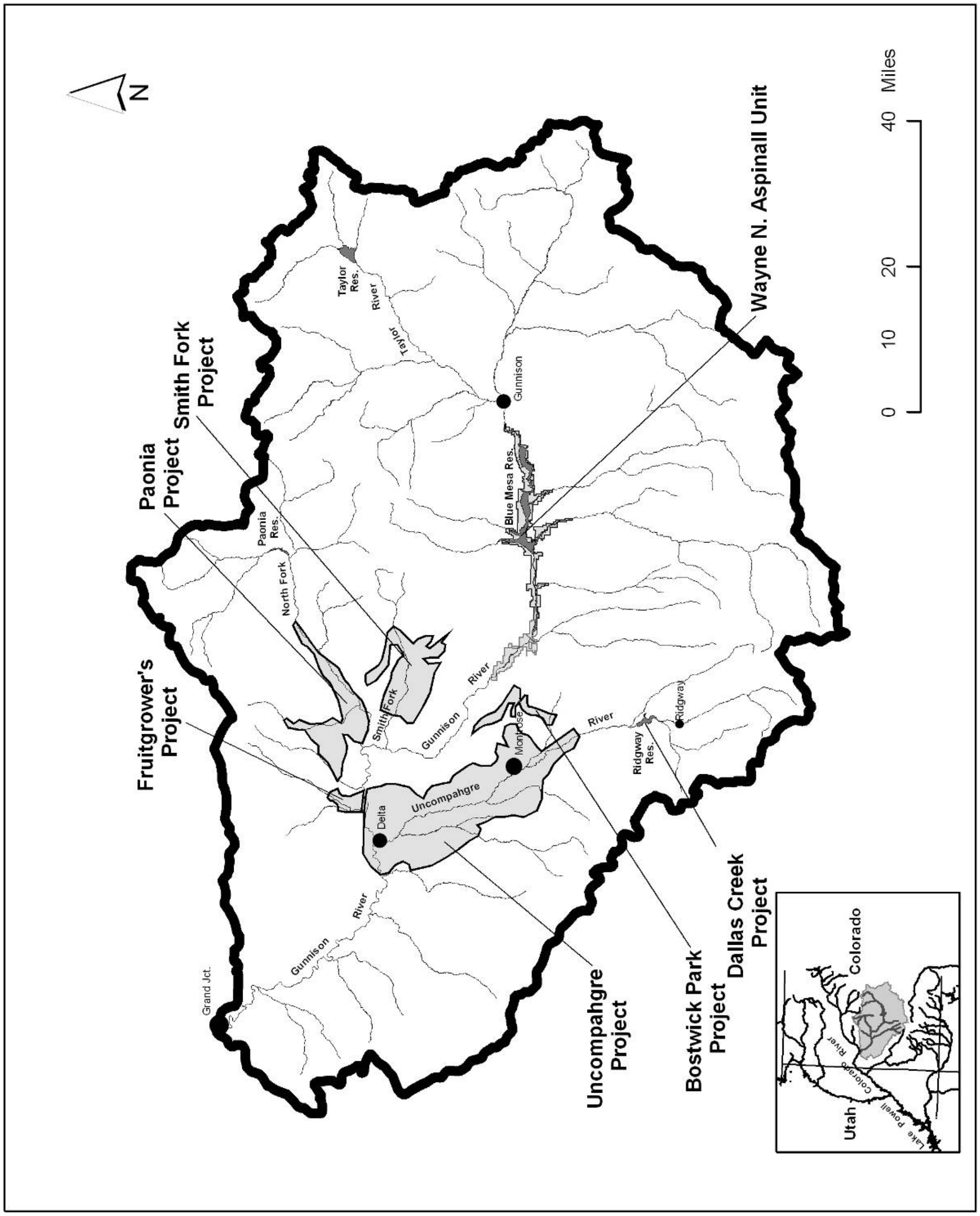
Vanicek, C.D. and R.H. Kramer. 1969. Life history of the Colorado squawfish, *Ptychocheilus lucius*, and the Gila chub *Gila robusta*, in the Green River in Dinosaur National Monument, 1964-1966. Transactions of the American Fisheries Society 98(2):193-208.

Wick, E.J., J.A. Hawkins, and C.A. Carlson. 1985. Colorado squawfish and humpback chub population and habitat monitoring, 1981-1982. Final Report. Endangered Wildlife Investigations SE-3-6. Colorado Division of Wildlife, Denver, Colorado.

Wick, E.J., J.A. Hawkins and T.P. Nesler. 1991. Occurrence of two endangered fishes in the Little Snake River, Colorado. Southwestern Naturalist 36(2):251-254.

Wiltzius, William. 1978. Some factors historically affecting the distribution and abundance of fishes in the Gunnison River. Colorado Division of Wildlife, Fort Collins. 215 pp

Attachment 1--Description of Gunnison Basin Reclamation Projects



DESCRIPTION OF OTHER RECLAMATION PROJECTS IN THE GUNNISON RIVER BASIN

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Bostwick Park Project

General Description
The Bostwick Park Project is in west-central Colorado near the city of Montrose. The project develops flows of Cimarron Creek, a tributary of the Gunnison River, for irrigation and for benefits to sport fishing and recreation. A full and supplemental supply of irrigation water is available for 6,100 acres of land. Recreation opportunities and important fishery benefits are provided at Silver Jack Reservoir.

Unit descriptions and facilities
Water storage is provided by Silver Jack Dam and Reservoir, constructed on Cimarron Creek. Project water is released from the reservoir to Cimarron Creek. The releases, along with usable natural flows, are diverted from the creek into the existing Cimarron Canal 2.5 miles below the dam, and conveyed 23 miles to the vicinity of the project land. Some water is released from the canal and used on lands in the Cimarron area. Most of the water is conveyed to the end of the canal at Cerro Summit and then delivered to the Hairpin and Vernal Mesa Ditches. The project-constructed Bostwick Lateral diverts water from the Vernal Mesa Ditch and conveys it across Bostwick Park through an 18-inch siphon to lands above the West Vernal Mesa Lateral.

Silver Jack Dam Silver Jack Dam is located on Cimarron Creek about 20 miles above the junction with the Gunnison River. The rolled-earthfill dam contains 1,278,140 cubic yards of material and has a structural height of 173 feet. Its crest is 1,050 feet long and 30 feet wide. The outlet works to Cimarron Creek in the right abutment has a capacity of 280 cubic feet per second with the reservoir at the normal water surface elevation of 8926.0 feet and a capacity of 160 cubic feet per second at the minimum water surface elevation of 8840.0 feet. The spillway on the right abutment is an uncontrolled ogee section with a capacity of 6,220 cubic feet per second at maximum water surface elevation. The reservoir has a total capacity of 13,520 acre-feet, including 12,820 acre-feet of active capacity and 700 acre-feet of inactive capacity. When filled to its normal water surface elevation, the reservoir has a surface area of 293 acres.

The 3.6-mile Bostwick Lateral was constructed to deliver water to full service lands above the West Vernal Mesa Lateral. Repair, extension, and some new construction of about 7.2 miles of drains were completed by the water users.

Operating agencies
Project irrigation facilities were turned over to the Bostwick Park Water Conservancy District for operation and maintenance on January 1, 1976.

Development History
The Bostwick Park area was settled in the early 1880's, followed by a second influx at the time of irrigation development in 1910. By 1930, the population had reached a peak of 75 to 80 families, but in 1960 decreased to about 40

families because of the trend toward larger farm units, use of modern labor-saving farm equipment, and drought conditions.

Investigations
The Bureau of Reclamation first reported on the Bostwick Park Project in a 1951 reconnaissance report on the Gunnison River Project. The plan presented in the 1961 feasibility study, upon which authorization was based, was essentially the same as the 1951 plan.

Authorization
The project was authorized as a participating project of the Colorado River Storage Project by Public Law 88-568, September 2, 1964 (78 Stat. 852). The primary purposes of the project are agriculture, recreation, and fish and wildlife.

Construction
Construction began at Silver Jack Dam late in 1966 and was completed in 1971. Silver Jack Reservoir was filled on June 10, 1971, and project water was available to supplemental service lands from existing ditches on a water rental basis during the 1971, 1972, and 1973 irrigation seasons. A negative declaration of environmental impact was filed July 21, 1972, for drainage rehabilitation and for replacement of the Vernal Mesa conduit. Construction of these facilities was completed during fiscal year 1974.

Benefits

Irrigation
The project furnishes a dependable late-season supply of irrigation water. Non-project supplies are generally abundant until the latter part of the irrigation season, but then fall off resulting in serious curtailment of crop yields. Project water from Cimarron Creek, and in small part from tributaries of Cedar Creek, is used as a full irrigation supply for lands not previously irrigated and as a supplemental supply for lands inadequately served.
Raising beef cattle and sheep are the major enterprises in the project area. Irrigated lands are used chiefly for the production of alfalfa, grass hay pasture, and small grains for livestock feed.

Recreation and Fish and Wildlife
The U.S. Forest Service developed recreation facilities under a cooperative arrangement with the Bureau of Reclamation. Facilities include access roads, campgrounds, a boat dock, trails, fences, landscaping, and an administration site. There were 84,500 visitor days to the reservoir area in 1996.

Flood Control
Bostwick Park Project has provided an accumulated $34,000 in flood control benefits from 1950 to 1999.

Dallas Creek Project

General Description
The Dallas Creek Project is located in west-central Colorado near the town of Ridgway. It is named after the Dallas Creek tributary of the Uncompahgre River, which in turn is a tributary of the Gunnison River in the Upper Colorado River Basin. The project area includes most of the Uncompahgre River Basin covering portions of Montrose, Delta, and Ouray Counties.

Unit descriptions and facilities
Ridgway Dam of the Dallas Creek Project was constructed on the Uncompahgre River in 1987 to increase water supplies for irrigation and municipal and industrial purposes, and to provide flood control. The project also includes recreational development at the reservoir and measures to enhance fishing opportunities on the Uncompahgre River, improve wildlife habitat, and mitigate wildlife losses caused by the reservoir development. No distribution facilities were constructed as part of the project. Water supplies are distributed through existing facilities or facilities constructed by the Tri-County Water Conservancy District or the water users.

Ridgway Reservoir is formed by Ridgway Dam on the Uncompahgre River about 6 miles north of Ridgway, Colorado, and 1 mile upstream from the confluence with Cow Creek. The reservoir has a capacity of 84,410 acre-feet of water and extends southwardly up the Uncompahgre River for 4.6 miles, with a 1-mile branch up the drainage of Alkali Creek. Active storage capacity is 59,396 acre-feet; dead and inactive capacity is 25,000 acre-feet. The surface area of the reservoir at the normal water surface elevation of 6,871.13 feet is 1,030 acres. Ridgway Dam is a rolled earthfill structure with a volume of 10,900,000 cubic yards and a height of 234 feet above streambed. The dam crest, at elevation 6886, is 2,460 feet long and 30 feet wide.

Operating agencies
The Tri-County Water Conservancy District is the general administrative agency for the project and is the contracting and marketing agency for all project water.

Development History
When the Ute Indians were moved to reservations in 1881, a rush of settlers poured into the Uncompahgre Valley attracted by new farming and ranching opportunities. The town of Delta was founded that year, followed by Montrose in 1882, Olathe in 1883, and Ridgway in 1890. Irrigated agriculture expanded rapidly throughout the valley with the construction of small, privately financed diversion structures. Restrictions imposed by private financing limited these developments to lands close to the streams.
In 1912, the Uncompahgre Project, one of the first Federal reclamation developments, began delivering water from the Gunnison River through the Gunnison Tunnel to lands around Montrose, Olathe, and Delta. After the successful irrigation of lands in the lower Uncompahgre Valley, interest developed in constructing a water delivery system for

potential farmlands on Log Hill Mesa, south of Ridgway, and along the upper Uncompahgre River and its tributaries.

Investigations

Soon after World War II, the Bureau of Reclamation began to study the possibility of a water project for the upper Uncompahgre River Basin. Early planning was directed toward irrigation. One of the first plans, called the Ouray Project, was never formally published, but it was the starting point for ensuing years of study. In February 1951, Reclamation published a reconnaissance report on the Gunnison River Project. One part of this extensive project was the Dallas Creek Unit, which included many of the features of the Ouray Project. After publication of the 1951 report, Reclamation studied a number of alternative plans. A plan to produce hydroelectric power in addition to irrigation power generation would not have interfered with irrigation proposals being considered, so it was added to the 1951 reconnaissance plan. Investigation of a dam site in Ironton Park indicated that it was not a geologically satisfactory site. This fact and the possibility of a conflict over water rights caused the proposal to be dropped from consideration.

The cost of the project, to eventually be repaid, was a problem for proposed irrigation developments in high elevation valleys like the upper Uncompahgre Basin because the cash value of crops produced per acre was comparatively low. This problem was largely alleviated for Dallas Creek in 1956 when the Congress passed the Colorado River Storage Project (CRSP) Act. One of the features of this act was to provide money from power revenues from CRSP facilities to assist designated participating irrigation projects in their repayment. The Dallas Creek Project was designated as one of these participating projects and was given priority for feasibility studies and financial assistance if authorized by the Congress.

After designation as a CRSP participating project, concentrated feasibility investigations were made of the project, which became a refinement of the 1951 reconnaissance plan, and published in a 1966 feasibility report. Municipal water was included in the plan for the first time. This plan was the basis for congressional authorization of the project in 1968. A definite plan report, published in November 1976, presents results of studies made since the project was authorized and outlines revisions of the project plan brought about by changing conditions. The final environmental impact statement was filed with the Council on Environmental Quality in September 1976 after a public hearing on the draft statement in Montrose, Colorado, on April 17, 1976.

Authorization

The Dallas Creek Project was authorized by the Colorado River Basin Act of September 30, 1968 (Public Law 90-537), as a participating project under the Colorado River Storage Project Act of April 11, 1956 (Public Law 84-485), based on the feasibility report of the Secretary of Interior transmitted to the Congress on May 3, 1966, and published as House Document 433, 89th Congress, 2nd Session. The project was constructed for municipal, industrial, agricultural, recreation, flood control, and fish and wildlife purposes.

Construction
Construction started in 1978, was completed in 1987, and Ridgway Reservoir first filled in 1990.

Benefits

Irrigation
Production of livestock, predominantly cattle and sheep, is the leading enterprise in the area. Crops consist primarily of livestock feeds such as alfalfa, meadow hay, pasture, and small grains. Irrigated lands in the area also produce pinto beans, malt barley, shelling and ensilage corn, alfalfa, onions, and some fruit. Project water supply for irrigation purposes totals 11,200 acre-feet, the largest portion of which is supplemental supplies for the Uncompahgre Project.

Domestic, Municipal, and Industrial
A water supply of 28,100 acre-feet is available for municipal and industrial uses in Colona, Montrose, Olathe, Delta, and surrounding rural areas.

Recreation and Fish and Wildlife
Recreational development includes facilities for picnicking, camping, boating, hiking, and enjoyment of the scenic setting. Measures to protect and enhance the fish and wildlife resources have been incorporated into the project plans. They include minimum flows in Uncompahgre River, a deer fence along a relocated highway, and acquisition of a wildlife range to offset losses associated with the reservoir. The Ridgway Recreation Area is administered by Colorado State Parks In 1996, visitation totaled 629,298.

Flood Control
Ridgway Reservoir is operated to aid in controlling snowmelt floods. Reservoir storage is evacuated to provide space for flood flows if heavy snowmelt is predicted. Although the reservoir is not operated specifically for control of rain floods, it aids in control as storage space is available in the reservoir in late summer when such floods normally occur. From 1950 to 1999, Dallas Creek Project had $53,000 in accumulated actual flood control benefits.

Dolores Project

General Description
The Dolores Project, located in the Dolores and San Juan River Basins in southwestern Colorado, uses water from the Dolores River for irrigation, municipal and industrial use, recreation, fish and wildlife, and production of hydroelectric power. It also provides flood control and aids in economic redevelopment. Service is provided to the northwest Dove Creek area, central Montezuma Valley area, and south to the Towaoc area on the Ute Mountain Ute Indian Reservation. A full and supplemental supply of irrigation water is available for 61,660 acres.

Unit descriptions and facilities
Primary storage of Dolores River flows for all project purposes is provided by McPhee Reservoir, formed by McPhee Dam and Great Cut Dike. Dawson Draw Reservoir, located west of McPhee Reservoir, was constructed specifically for fish and wildlife enhancement and is supplied primarily from irrigation return flows.

An average annual supply of 90,900 acre-feet of water is provided to 27,860 acres of full service land in Dove Creek, 7,500 acres of full service land in Towaoc, and 26,300 acres of supplemental service land in Montezuma Valley. Water for the Dove Creek area is pumped from McPhee Reservoir by the Great Cut Pumping Plant and conveyed 39.5 miles through the Dove Creek Canal and its 7.6-mile branch, the South Canal. Water for the Towaoc area is conveyed 48 miles from the reservoir by the Dolores Tunnel and the Dolores and Towaoc Canals. Both areas are served by sprinkler irrigation systems. The Montezuma Valley area is served by releases at Great Cut Dike and the Dolores Tunnel and Canal to an existing gravity distribution system.

Powerplants are located on McPhee Dam and the Towaoc Canal to generate an annual average of 36,578,000 kilowatt-hours, which enters the Colorado River Storage Project power transmission system. The McPhee Dam facility operates year-round on fishery releases from McPhee Reservoir, while the Towaoc Canal plant operates from April to October on the irrigation water supply conveyed through the canal.

McPhee Dam, located on the Dolores River, is a rolled earth, sand, gravel, and rockfill structure with a volume of approximately 6,230,000 cubic yards. The crest of the dam is 270 feet high above streambed, 1,300 feet in length, and 30 feet wide. A gated spillway located in the right abutment includes a concrete chute leading to a stilling basin. The outlet works, located in the left abutment of the dam, has two separate intake structures, and a total capacity of 5,000 cubic feet per second. Great Cut Dike is a rolled earthfill structure with a crest length of 1,900 feet, and crest width of 30 feet. It has a maximum height of 64 feet above original ground surface. The embankment has a volume of about 189,000 cubic yards.

McPhee Reservoir was created with the construction of McPhee Dam and the Great Cut Dike in a saddle on the Dolores-San Juan Divide. The reservoir has a total capacity of 381,195 acre-feet, including 229,200 acre-feet of active capacity, 151,900 acre-feet of inactive capacity, and 95 acre-feet of dead storage. The water surface area totals 4,470 acres at the top of the active capacity at an elevation of 6924.0 feet. The reservoir extends approximately 10 miles up the Dolores River, 4 miles up Beaver Creek, 1 mile up Dry Creek, 2 miles up House Creek, and 2 miles up the Great Cut saddle to the dike.

Great Cut Pumping Plant at Great Cut Dike consists of ten vertical, mixed-flow pumping units. Eight of the pumps are multi-stage and lift water from the reservoir through a discharge line into the Dove Creek Canal. The two remaining pumps lift water through a discharge line into the "U" lateral if the reservoir water surface is too low for gravity releases. Annual energy requirements for the eight pumps average about 5,800,000 kilowatt-hours. The additional two require an annual average of 99,000 kilowatt-hours.

Six pumping plants, including four along the Dove Creek Canal and two along the South Canal, provide water to pipe laterals for sprinkler irrigation. The average annual energy requirement for operating the plants is approximately 10,890,000 kilowatt-hours.

The Dove Creek Canal heads at the end of the pump discharge line at Great Cut Dike and extends northwest for 39.5 miles to Monument Creek Reservoir. It has an initial capacity of 380 cubic feet per second and a terminal capacity of 30 cubic feet per second. It includes a turnout to the South Canal and to the four sprinkler pumping plants.
The South Canal heads on the Dove Creek Canal near Pleasant View and extends 7.6 miles to the south and west. It has an initial capacity of 150 cubic feet per second and a terminal capacity of 35 cubic feet per second. It includes turnouts to three pressure pipeline sprinkler irrigation systems.

The Dolores Tunnel was drilled through the Dolores-San Juan divide about 2 miles west of the town of Dolores and 1 mile downstream from the existing tunnel of the Montezuma Valley Irrigation Company. Maximum capacity is 520 cubic feet per second.

The Dolores Canal heads at the outlet of the Dolores Tunnel and extend for 1.3 miles to the south and east. The canal replaced approximately 0.5 mile of the existing West Lateral and 0.8 mile of the existing East Lateral. Initial capacity is 520 cubic feet per second; the terminal capacity is 475 cubic feet per second.

The Towaoc Canal heads on the Dolores Canal 1.1 miles below the outlet of the Dolores Tunnel and extends southward for 45.4 miles to the full service lands in the Towaoc area. The canal is earth lined for 32.8 miles and concrete lined for 7.5 miles. It has an initial capacity of 135 cubic feet per second and a terminal capacity of 86 cubic feet per second.

The Cortez-Towaoc Pipeline heads just above the terminus of the Dolores Canal and extends southward 19.5 miles to near Towaoc. The initial section to Cortez carries 17.3 cubic feet per second and the remainder extending to Towaoc carries 2.9 cubic feet per second.

Twelve lateral systems with a total of 84.7 miles were constructed to deliver water to farms in the Dove Creek and Towaoc areas. Project drainage facilities were provided for both areas.

The McPhee Dam Powerplant consists of a penstock located within the outlet tunnel of the dam, a single turbine and generator at the base of the dam, and a 4.5 mile, 13.8-kilovolt transmission line to Great Cut Switchyard. Plant capacity is 990 kilowatt-hours, and produces an average of 6,260,000 kilowatt-hours annually.

Towaoc Canal Powerplant capacity is10.5 megawatts, and produces an average of 30,318,000 kilowatt-hours annually. A 78-inch-diameter, buried concrete pipe penstock heads at a project works on the Dolores Canal and extends southwest for about 11,700 feet into Hartman Draw to the powerhouse. The powerhouse consists of two turbines connected to two 4.5-megawatt generators and one turbine connected to a 1.5-megawatt generator.

Operating agencies
The Dolores Water Conservancy District administers project and joint-use facilities within its boundaries, and the Ute Mountain Ute Indian Tribe and the Bureau of Indian Affairs administer facilities serving the reservation. The Forest Service, Bureau of Land Management, and Colorado Division of Wildlife participate in managing recreational and cultural facilities and wildlife lands.

Development History
In 1873, modern development began in southwest Colorado when the Federal Government opened the nearby San Juan Mountains to mining. In the early 1880's, settlers moved into the Montezuma Valley. These early settlers began farming the land but soon realized that to ensure good harvests they would need more water than was available from the small streams in the Montezuma Valley. To meet this need, they built irrigation canals that conveyed water from the Dolores river to the fertile but dry valleys in the San Juan river Basin. The canals did help, but they carried too little water and shortages continued to plague the farmers and residents. The Dolores Project ensures an adequate supply of water to meet existing and future agricultural and municipal needs.

Investigations
Definite plan studies were made and published in April 1977. The report updated the physical data and included revised financial and economic analysis of the project, based on the feasibility report transmitted to the Congress on March 17, 1966, which led to authorization.

Anticipated environmental impacts were detailed in the final environmental statement filed with the Council on Environmental Quality on May 9, 1977. Included in the studies were analyses of water resources, water quality, fisheries, wildlife, threatened or endangered species, scenery, economic and social conditions, historic and archeological sites, recreation, and a summary of unavoidable adverse impacts with short-term losses compared to long-term gains.

Archeological investigations disclosed that although the project would not affect any properties listed on the National Register of Historic Places, it could disturb about 487 known archeological sites, either within proposed rights-of-way or in other areas that would be altered by project construction. An excavation program preceded each stage of construction to remove and preserve all significant findings.

Authorization
The Dolores Project was authorized by the Colorado River Basin Act of September 30, 1968 (Public Law 90-537), as a participating project under the Colorado River Storage Project Act of April 11, 1956 (Public Law 84-485).

Construction
A ground breaking ceremony for the project was held September 24, 1977, at the site of the Great Cut Dike, northwest of Cortez.

Benefits

Irrigation
Project water is available for 61,660 acres and benefits the area's economy by increasing agricultural production, and strengthening service-related enterprises dependent on agriculture. Main crops are alfalfa, pasture, barley, oats, and corn silage for livestock feed.

Domestic, Municipal, and Industrial
The annual municipal and industrial water supply of 8,700 acre-feet will permit a moderate but healthy future growth in the area.

Recreation and Fish and Wildlife
Water releases from McPhee Reservoir created a downstream fishery. Releases from the reservoir in anticipation of snowmelt flows are managed to benefit white-water boaters. The project reservoirs and facilities provided new recreation opportunities for the public. Land acquired and managed for wildlife conservation created valuable and unthreatened habitat for a variety of wildlife species.

Hydroelectric Power
The average annual energy production of McPhee Dam and Towaoc Canal Powerplants is in excess of that needed by the project. Rather than draining the nation's energy resources, the Dolores Project generates environmentally clean power which helps alleviate the problems caused by dwindling fossil fuel supplies.

Flood Control
McPhee Reservoir provides flood protection for downstream landowners. The Dolores Project has provided accumulated actual benefits of $2,000 between 1950 and 1999.

Fruitgrowers Project

General Description
The Fruitgrowers Dam Project in southwestern Colorado furnishes irrigation water to nearly 2,700 acres of land immediately downstream from the dam. Structures built by the Bureau of Reclamation are Fruitgrowers Dam, Dry Creek Diversion Dam, and Dry Creek Diversion Ditch. Other diversion structures and the canal and lateral system were constructed by private interests.

Unit descriptions and facilities
Fruitgrowers Reservoir is filled from the natural flow of Alfalfa Run and by diversions from Surface and Dry Creeks. The flow of Dry Creek is diverted by the Dry Creek Diversion Dam, and conveyed through the Dry Creek Diversion Ditch. Surface Creek water is carried through the privately owned Alfalfa Ditch. Water stored in Fruitgrowers Reservoir is released and delivered to project lands through a privately owned system of canals and laterals.

The dam, located on Alfalfa Run, is 3 miles north of Austin, Colorado. It is an earthfill, rock-faced structure, 55 feet high and 1,520 feet long, containing 136,000 cubic yards of material. The reservoir stores a total of 4,540 acre-feet of water. The spillway, located on the left side of the dam, is an uncontrolled structure (meaning flows aren't regulated). A 76-foot-long concrete-lined channel discharges into a stilling basin which slows the velocity and reduces the energy of the water. The outlet works consists of one 3-foot diameter pipe controlled by two slide gates. This diversion dam is 13 feet high and 36 feet long. It contains 200 cubic yards of concrete. The Dry Creek Diversion Ditch is about 3 miles long and has a capacity of 100 cubic feet per second.

Operating agencies
The Orchard City Irrigation District assumed operation and maintenance of the project works in March 1940.

Development History
Irrigation of lands now encompassed by the Fruitgrowers Dam Project was initiated about 1890. In 1898, settlers built a small dam on Alfalfa Run to provide water storage for their irrigation system. This dam failed on June 13, 1937, resulting in extensive damage. Since the highly developed agricultural area could not be sustained without storage of the late summer water supply, the settlers requested that the Bureau of Reclamation investigate building a new dam.

Investigations
On the basis of their studies, Reclamation began work on the project in May 1938.

Authorization
Under section 4 of the act of June 25, 1910 (36 Stat. 835), the Secretary of the Interior recommended, and the President approved, construction of the project in January 1938. The primary purpose of the project is agriculture.

Construction
Reclamation completed construction of the new dam in time for stored water to be delivered to project lands for the 1939 irrigation season.
Benefits

Irrigation
The project provides supplemental irrigation for nearly 2,700 acres of land. Principal crops are fruit, small grains, corn, alfalfa, and pasture.

Recreation and Fish and Wildlife
When full, Fruitgrowers Reservoir has a surface area of 476 acres. It receives very little recreation use; however, bird watching is becoming increasingly popular. The reservoir is a major migration stop and nesting site for a variety of shorebirds and waterfowl.

Flood Control
Although there is no specific reservoir capacity assigned for flood control, the Fruitgrowers Project has provided an accumulated $4,000 in flood control benefits from 1950 to 1999.

Paonia Project

General Description
The Paonia Project, in west-central Colorado, provides full and supplemental irrigation water supplies for 15,300 acres of land in the vicinity of Paonia and Hotchkiss. Project construction includes Paonia Dam and Reservoir and enlargement and extension of Fire Mountain Canal. Paonia Dam controls and regulates the runoff of Muddy Creek, a tributary of the North Fork of the Gunnison River. No new irrigation laterals have been provided by the project.

Unit descriptions and facilities
Paonia Reservoir stores the flows of Muddy Creek upstream of its confluence with the North Fork of the Gunnison River. Downstream, the Fire Mountain Diversion Dam and Canal divert flows from the river for delivery to project lands in the Fire Mountain Division. Leroux Creek Division water, used downstream of the Fire Mountain Canal extension, is exchanged with the Fire Mountain Canal and Reservoir Company. These shares are used as project water by the Leroux Creek Water Users Association for irrigation of Leroux Division lands above the Fire Mountain Canal. Fire Mountain Division water is then used by the Leroux Division lands on Rogers Mesa downstream of the Fire Mountain Canal system. Improvement of existing small reservoirs in the Leroux Creek Division was accomplished independently by water users.

Paonia Dam is on Muddy Creek about 1 mile upstream of its junction with Anthracite Creek, which in turn forms the North Fork of the Gunnison River. The dam is an earthfill structure containing 1,302,000 cubic yards of embankment with an interior impervious zone, blanketed upstream and downstream by zones of sand, gravel, and cobbles. The upstream face is protected by a layer of riprap and the downstream face by a layer of rockfill. The crest of the dam is 35 feet wide and 770 feet long; the structure stands 199 feet above foundation.

The outlet works on the right abutment of the dam consists of a concrete intake tower, concrete-lined tunnel, gate chamber near the dam axis, and a combination stilling basin for both the outlet works and spillway. The outlet works also includes a concrete shaft house and concrete-lined shaft and add it between the gate chamber and access shaft. The capacity of the outlet works is 1,250 cubic feet per second at maximum water surface elevation.

The spillway, also on the right abutment, consists of an uncontrolled ogee crest and open chute having a design capacity of 12,500 cubic feet per second. The chute joins the combined outlet works-spillway stilling basin.

Paonia Reservoir has a surface area of 334 acres with a total capacity of 20,950 acre-feet and an active capacity of 18,150 acre-feet.

Fire Mountain Diversion Dam, located on the North Fork of the Gunnison River near Somerset, is a timber sheet-piling, rockfill structure. It has a height above streambed of 11 feet. Fire Mountain Canal extends 34.7 miles along the north side of the valley. It has an initial capacity of 200 cubic feet per second, reducing to 100 cubic feet per second at the Leroux Creek crossing.

Operating agencies
Operation and maintenance was assumed by the North Fork Water Conservancy District on June 1, 1962. By contract, the district transferred the physical operation and maintenance of the project to the Fire Mountain Canal and Reservoir Company.

Development History
Mining led to the early settlement of western Colorado and brought the area's first railroad service. The Ute Indians originally occupied west-central Colorado, including the valley of the North Fork of the Gunnison River. Early efforts to penetrate the area were resisted by the Utes until a compromise agreement with the Government was reached on September 4, 1881, and the Utes were moved to the Uintah Reservation in the Territory of Utah.

Water rights in the valley date from 1882. The development of irrigation facilities proceeded rapidly until, by the turn of the century, the late summer natural flow of the river had become heavily appropriated. Settlement and population growth were rapid in early years, but development of the area slowed by 1920. Agricultural settlement has remained more or less static since that time, although the population has increased.

Investigations
In 1934, the State of Colorado began investigating a number of reservoir sites, including five in the North Fork watershed. As a result of these investigations and activities of the local water users, the Bureau of Reclamation commenced investigation of storage possibilities in the North Fork Valley in 1936. A report issued by the Bureau of Reclamation in August 1938 suggested development of a reservoir at the Horse Ranch site on Anthracite Creek to serve lands of the Fire Mountain Canal and also of a reservoir

at the Beaver dam site on the East Fork of Minnesota Creek to supplement the water supply for ditches diverting from Minnesota Creek. Anthracite Creek and Minnesota Creek are tributaries of the North Fork of the Gunnison River. On the strength of this report, the Paonia Project was authorized on March 18, 1939, by Presidential approval of the findings of feasibility of the Secretary of the Interior, dated March 16, 1939. Subsequent findings prompted issuance of a revised report in 1940 dealing only with the Fire Mountain Division. This report proposed that the Spring Creek Reservoir site on East Muddy Creek, another tributary of the North Fork, be developed by the Bureau of Reclamation and that the Fire Mountain Canal be enlarged by the water users in a 10-year development period during which no payments would be required for the storage dam. Funds for the canal enlargement were to be derived from charges made for the use of Spring Creek Reservoir water and from revenues from the sale of Leroux Creek water rights in the area to be served by an extension of the Fire Mountain Canal. This plan, however, was not favored by water users and authorization was not requested.

In 1946, the project plan was further revised to include a total of 14,750 acres of land to be benefited, to provide 4,000 acre-feet of surplus reservoir capacity, to provide for enlargement and improvement of the Overland and Fire Mountain Canals, and to provide for transfer of the use of water to upstream lands on Leroux Creek under two alternative plans. The project was authorized on June 25, 1947, by the 80th Congress. When bids for construction of Spring Creek Dam were opened on August 3, 1948, the low bid was 54 percent above the engineer's estimate and exceeded the total expenditure authorized for all features. No justification could be found for such high bids, and all bids were rejected. It was determined, however, that enlargement and extension of the Fire Mountain and Overland Canals were feasible undertakings independent of the storage feature. Because repayment contracts had been executed between the Government and the water users, construction of the Fire Mountain Canal was commenced.

In a February 1951 report, the project plan was revised to include an 18,000 acre-foot reservoir at the Paonia site, additional extension of the Fire Mountain Canal, enlargement of Overland Ditch, and construction of a siphon and pumping plant to convey irrigation water from the Fire Mountain Canal to 2,010 acres of land along Minnesota Creek. This plan would have provided irrigation service for 14,830 acres of irrigated land and 2,210 acres of unirrigated land. Development was authorized in 1956 as a participating project with the Colorado River Storage Project.

Since the 1956 authorization, water users in the Minnesota Creek area have withdrawn from the project in favor of private development of a reservoir on that stream. Therefore, the Minnesota Siphon and Pumping Plant and service to the Minnesota Creek lands were eliminated from the plan. It also was determined that existing ditches from Leroux Creek were adequate to convey usable flows of that stream, and enlargement of Overland Ditch was deleted from the plan. In the definite plan studies, it was determined that the total reservoir capacity should be increased to 21,000 acre-feet to provide more space for sediment retention. Irrigable acreages were reduced to 15,300.

Authorization
Construction under the 1938 plan was authorized by the President under Reclamation law on March 18, 1939.

The revised plan was authorized by the Congress on June 25, 1947. The project was reauthorized as a participating project under the Colorado River Storage Project by the act of April 11, 1956 (70 Stat. 105). The primary purpose of the project was for agriculture.

Construction
The contract for the construction of Paonia Dam was awarded January 7, 1959, and work was completed in January 1962. Contracts for extension and lining of Fire Mountain Canal were awarded in 1959 and 1960, and work was completed in 1962.

Benefits

Irrigation
The project assures a full supply of water for irrigated lands. The general type of farming formerly practiced in the area has been continued with project development, but the additional irrigation supplies make possible more intensive crop production. Livestock feed and apples, peaches, and cherries are the major crops grown. Dairy and beef cattle are the principal livestock of the area.

Recreation and Fish and Wildlife
Fishing, hunting, picnicking, and water sports are available at Paonia Reservoir. Recreation facilities are administered by Colorado State Parks. Visitor days totaled 8,345 in 1996.

Flood Control
Flood dangers on North Fork River are reduced by emptying the reservoir each year and by reserving storage space through forecasts of snowmelt runoff, and regulation of flood flows. The Paonia Reservoir has 2,280 acre feet of capacity assigned to flood control. The Paonia Project has provided an accumulated $253,000 in flood control benefits from 1950 to 1999.

Smith Fork Project

General Description
Flows of Smith Fork, Iron, Mud, and Alkali Creeks are regulated and utilized by the Smith Fork Project in west-central Colorado. The project, about 30 miles southeast of Delta, Colorado, supplements the irrigation water supply for approximately 8,200 acres in Delta and Montrose counties and provides a full water supply for 1,423 acres of land previously not irrigated. Construction features of the project include Crawford Dam and Reservoir, Smith Fork

Diversion Dam, Smith Fork Feeder Canal, Aspen Canal, Clipper Canal, and recreation facilities.

Unit descriptions and facilities
Crawford Dam is on Iron Creek, a tributary of the Smith Fork about 1 mile south of Crawford, Colorado. The Crawford Reservoir regulates flows of Iron Creek and its tributaries as well as the surplus flows of the Smith Fork of the Gunnison River, diverted to the reservoir by the feeder canal. Small quantities of reservoir storage water are released to Iron Creek and diverted by several small private ditches. The remainder is released to Aspen Canal for conveyance to private ditches for distribution. Some of the storage releases through Aspen Canal replace former direct flow diversions from Smith Fork, permitting additional direct flow diversions for project land higher on the stream.

Crawford Dam is an earthfill structure 162 feet high and 580 feet long, with a volume of 1,006,000 cubic yards. The uncontrolled overflow spillway is in the left abutment of the dam and has a capacity of 1,400 cubic feet per second. The outlet works in the right abutment of the dam carries water through a 34-inch-diameter steel pipe controlled by four 2.25-foot-square high-pressure gates. Maximum discharge capacity to Aspen Canal is 125 cubic feet per second. Crawford Reservoir has a total capacity of 14,395 acre-feet and an active capacity of 14,064 acre-feet. The reservoir has a surface area of 406.2 acres.

Smith Fork Diversion Dam, at the head of Smith Fork Feeder Canal, consists of a concrete ogee weir and embankment wings. The dam is about 3 miles northeast of Crawford, stands 10 feet above streambed, has a total crest length of 790 feet, and a weir crest length of 34.6 feet. Diversion capacity of the structure is 80 cubic feet per second.

In the vicinity of Crawford, the earth-lined Smith Fork Feeder Canal originates at Smith Fork Diversion Dam and runs southwesterly to Crawford Reservoir. The 2.4-mile-long canal has an initial capacity of 80 cubic feet per second.

Aspen Canal heads at Crawford Dam and runs 5.8 miles in a northerly direction. The canal has an initial capacity of 125 cubic feet per second.

Clipper Canal feeds from Aspen Canal and runs to the west a distance of about 0.5 mile. The initial capacity of the canal is 60 cubic feet per second.

Operating agencies
Operation and maintenance of the project was turned over to the Crawford Water Conservancy District on January 1, 1964.

Development History
Delta County, along with most of western Colorado, was originally inhabited by the Ute Indians. Early settlement of the area was retarded by hostility between the Utes and the immigrants. In 1881, a compromise agreement was reached between the Federal Government and the Utes which required the Indians to locate in the Uintah Reservation

in the Territory of Utah. After this agreement, settlement of the area progressed rapidly. Most of the impetus of the initial settlement period was provided by discoveries of rich deposits of gold, silver, and other minerals in the mountainous areas near the Continental Divide. Agricultural development proceeded at a slower rate but was much more uniform and stable. Farms were developed along the valleys, towns were established near the mines and the agricultural communities, and construction of railroads to the trade and mining centers was begun.

Investigations
The Smith Fork Project was mentioned briefly in Reclamation's basin-type report of March 1946 on the Colorado River. In 1951, Reclamation issued a detailed report on the Smith Fork Project as a supplement to the 1951 report on the Colorado River Storage Project and participating projects. This second report, amended in October 1953, was the basis on which the project was authorized.

Authorization
The project is one of the initial participating projects authorized with the Colorado River Storage Project by the act of April 11, 1956 (70 Stat. 105). The primary purpose of the project is agriculture.

Construction
Construction was begun on Crawford Dam in 1960 and on all other major features in 1961. All construction was completed in 1962.

Benefits

Irrigation
An improved irrigation supply permits new lands to be irrigated and permits better crop yields on lands previously inadequately watered. Predominant crops include alfalfa, grass hay, pasture, barley, oats, wheat, and corn. Feed production is used for livestock, primarily cattle and sheep.

Recreation and Fish and Wildlife
Recreation at Crawford Reservoir is administered by the Colorado State Parks and consists of fishing, boating, and camping. Visitor days in 1996 totaled 109,704. In 1997, the State of Colorado and Bureau of Reclamation upgraded facilities at Crawford State Park to include accessible features for people with disabilities. There are 45 campsites with hookups and 21 without. Showers and flush toilets are available. A fishing trail with platforms and an accessible dock are also available.

Flood Control
Although there is no specific reservoir capacity assigned for flood control, the Smith Fork Project has provided an accumulated $14,000 in flood control benefits from 1950 to 1999.

Uncompahgre Project

General Description
The Uncompahgre Project is on the western slope of the Rocky Mountains in west-central Colorado. Project lands surround the town of Montrose and extend 34 miles along both sides of the Uncompahgre River to Delta, Colorado. Project features include Taylor Park Dam and Reservoir, Gunnison Tunnel, 7 diversion dams, 128 miles of main canals, 438 miles of laterals, and 216 miles of drains. The systems divert water from the Uncompahgre and Gunnison Rivers to serve over 76,000 acres of project land.

Unit descriptions and facilities
The project plan provides for storage in Taylor Park Reservoir on the Taylor River, which is a part of the Gunnison River Basin, and diversion of water from the Gunnison River by the Gunnison Diversion Dam through the Gunnison Tunnel and the South Canal to the Uncompahgre River. To distribute the waters of the Gunnison and Uncompahgre Rivers, the South and West Canals were constructed and the larger existing private canals, that take water directly from the Uncompahgre River, were purchased, then enlarged and extended. Laterals were constructed to deliver water from the South Canal to project lands.

Taylor Park Dam is on the Taylor River, a tributary of the Gunnison River. The dam is a zoned earthfill structure 206 feet high, with a crest length of 675 feet and a volume of 1,115,000 cubic yards. It creates a reservoir with a storage capacity of 106,200 acre-feet. The spillway is an overflow-type weir crest 180 feet long with a capacity of 10,000 cubic feet per second. The outlet works is a horseshoe tunnel with a diameter of 10 feet, and a capacity of 1,500 cubic feet per second.

The Gunnison Diversion Dam on the Gunnison River, about 12 miles east of Montrose, is a timber-crib weir with concrete wings and a removable crest. The dam has a structural height of 16 feet. It diverts Gunnison River direct flows, as well as releases from the Taylor Park Dam into the Gunnison Tunnel. The Gunnison Tunnel was designed as a rectangular section 11 feet wide and 12 feet high, with an arch roof. A number of modifications have been made since the original construction. It is 5.8 miles long and has a capacity of 1,300 cubic feet per second.

The South Canal extends from the end of the Gunnison Tunnel generally southwest 11.4 miles to the Uncompahgre River. Part of the canal is concrete lined; the remainder is unlined. The canal has an initial capacity of 1,010 cubic feet per second.

West Canal extends generally northwest about 21 miles from the Uncompahgre River beginning at the terminal structure of the South Canal with the river. This unlined canal as an initial capacity of 172 cubic feet per second. The West Canal is diverted directly from the South Canal and a timber and metal flume carries the canal across the Uncompahgre River. There is a small diversion for winter flows directly from the Uncompahgre River.

Montrose and Delta Diversion Dam is on the Uncompahgre River about 8 miles south of Montrose. The dam is a concrete gate structure with radial control and sluiceway gates. The unlined canal extends generally northwest about 40 miles from the diversion point and has a diversion capacity of 563 cubic feet per second. The original dam and canal were privately constructed and later purchased and rehabilitated by Reclamation as part of the Uncompahgre Project. A new structure was built in 1963 with a diversion capacity of 550 cubic feet per second.

Loutzenhizer Diversion Dam is on the Uncompahgre River about 2 miles south of Montrose. It was a pile-and-timber weir with a concrete apron but was rebuilt by the water users into a concrete weir and apron with radial gates. The dam has a structural height of 24 feet. The canal extends generally northwest 14.5 miles from the diversion dam and has a diversion capacity of 120 feet per second. The original dam and canal were privately constructed and purchased by Reclamation in 1908.

Selig Diversion Dam is on the Uncompahgre River about 5 miles northwest of Montrose. It has a timber-gated sluiceway with uncontrolled concrete overflow weir and concrete stilling basin. Its structural height is 25 feet. The canal extends generally north about 20 miles from the diversion dam. This unlined canal has a diversion capacity of 320 cubic feet per second. The original dam and canal were privately constructed and purchased by Reclamation in 1914.

Located on the Uncompahgre river about 8 miles northwest of Montrose, the Ironstone Diversion Dam is a concrete structure with radial control and sluiceway gates with a concrete wing. The structural height is 17 feet. The unlined canal runs 14 miles northwest from the diversion dam. The diversion capacity of the canal is 400 cubic feet per second. The original dam and canal were privately constructed and were acquired by Reclamation in 1915.

Located on the Uncompahgre river about 10 miles northwest of Montrose, the East Canal Diversion Dam is a concrete and timber weir with an earth embankment wing. The structural height is 16 feet. The unlined canal extends 10.6 miles north from the diversion dam. Its diversion capacity is 165 cubic feet per second. The original dam and canal were privately constructed and were acquired by Reclamation in 1911.

The Garnet Diversion Dam is on the Uncompahgre River about 15 miles northwest of Montrose. The dam is a concrete-surfaced rockfill weir, and has a structural height of 8 feet. Garnet Canal is unlined and extends 10.7 miles northwest from the diversion dam. Its diversion capacity is 75 cubic feet per second. The original dam and canal were constructed by private interests and purchased by the Bureau of Reclamation in 1914.

There are 438 miles of laterals which distribute water to project lands. A system of subsurface drains totaling 216 miles has been constructed.

Operating agencies
The project is operated and maintained by the Uncompahgre Valley Water Users Association.

Development History
The lands comprising the project area were formerly part of the Ute Indian reservation. Settlement rapidly followed cession of the land by the Indians to the United states. By 1903, about 30,000 acres in the Uncompahgre Valley were irrigated by private systems which included five diversion dams on the Uncompahgre River. As the possibilities for greater use of irrigation water were evident, a larger development by the State of Colorado was started in 1901 but was abandoned. Work by the Reclamation Service began in 1903.

Active support for driving a tunnel from Gunnison River to the Uncompahgre Valley to obtain additional water was solicited as early as 1890. In 1894, the Geological Survey completed a reconnaissance survey and found it was too expensive an undertaking for local interests, but in 1901 the state of Colorado appropriated $25,000 to start the tunnel. Only 900 feet were driven before the funds were exhausted. In 1901, construction surveys of the project were begun by the Geological Survey, and the general scheme of the project was outlined in its first report. After the passage of the Reclamation Act in 1902, the Uncompahgre Valley was selected for immediate development. The original surveys by the Geological survey, plus the investigational work carried out by the Reclamation Service, served as a basis for authorization of the project in 1903.

Authorization
The Uncompahgre Project (originally called the Gunnison Project) was authorized by the Secretary of the Interior on March 14, 1903, under the provisions of the Reclamation Act. Rehabilitation of the project and construction of Taylor Park Dam was approved by the President on November 6, 1935.

Construction
Construction began in July 1904, and the first water for irrigation was available during the season of 1908 from the Uncompahgre River. The Gunnison Tunnel was completed in 1909, and the Gunnison Diversion Dam was completed in January 1912. The project was transferred to the Uncompahgre Valley Waters Users Association for operation and maintenance in 1932. Taylor Park Dam, built from funds allotted under the National Industrial Recovery Act, was completed in 1937. Other improvements made during the same period included enlargement, lining, and smoothing portions of the Gunnison Tunnel, constructing concrete and steel structures to replace some of the worn out wooden structures in the privately constructed irrigation systems, relining portions of the canals, and constructing a drainage system to relieve and prevent water logging of land.

Recent Developments
This project is within the Colorado River basin and is part of the Colorado River Basin Salinity Control Program., specifically The Lower Gunnison Basin Salinity Control Unit

Benefits

Irrigation
Almost 76,300 acres of land receive a full irrigation water supply from the facilities of the project. Principal crops are alfalfa, wheat, corn, oats, potatoes, beans, barley, onions, and fruit.

Recreation and Fish and Wildlife
Free camp and picnic grounds have been provided by the Forest Service at Taylor Park Reservoir. Cabins are available at privately owned resort developments in the area. Camping, picnicking, swimming, and boating are popular activities, and fishing is good for rainbow, and brown trout. Some brook and native trout also are caught.
Flood Control
Although there is no specific reservoir capacity assigned for flood control, the Uncompahgre Project has provided an accumulated $639,000 in flood control benefits from 1950 to 1999.

Table 1-Average Annual Project Depletions

Project	Average Annual Depletion (Acre-feet)	Existing Section 7 Coverage
Wayne Aspinall Unit (Evaporation)	7,000-9,000	No
Wayne Aspinall Unit (Water Service Contracts)	<1,000	Yes
Bostwick Park Project	4,000	No
Dallas Creek Project	17,200	Yes
Dolores Project*	99,200	Yes
Fruitgrowers Project	4,100	No
Smith Fork Project	6,000	No
Paonia Project	10,000	No
Uncompahgre Project	155,000	No
Total	**335,300-337,300**	

*Existing Biological Opinion for the Dolores Project references release from upstream projects.

Attachment 2—Summary of Flow Recommendations to benefit endangered fishes in the Colorado and Gunnison rivers.

The Flow Recommendations generally call for higher spring peak flows and lower base flows to produce a more natural river hydrograph. Flow Recommendations are designed to meet the physical and biological needs of the endangered fishes. A summary of the Flow Recommendations is provided below. To review the entire report, go to http://www.usbr.gov/uc/wcao/rm/aspeis/pdfs/GunnCoFlowRec.pdf

RECOMMENDATION GOALS

→ Provide habitats and conditions that provide for spawning and reproduction;

→ Provide in-channel habitat for all life stages for endangered fish;

→ Provide backwater habitat and conditions necessary for overall fish health; and

→ Provide base flows that promote growth and survival of young fish during summer, autumn, and winter.

HYDROLOGIC CATEGORIES (Runoff varies year to year, dependent on snowpack)

→ **Wet (0--10% exceedance).**—A year during which the forecasted April—June runoff volume has been equal or exceeded in 10% or less of the years since 1937. This hydrologic condition has a 10% probability of occurrence.

→ **Moderate Wet (10--30% exceedance).**—A year during which the forecasted April—July runoff volume has been equaled or exceeded in 10-30% of the years since 1937. This hydrologic condition has a 20% probability of occurrence.

→ **Average Wet (30—50% exceedance).**—A year during which the forecasted April—July runoff volume has been equaled or exceeded in 30—50% of the years since 1937. This hydrologic condition has a 20% probability of occurrence.

→ **Average Dry (50—70% exceedance).**—A year during which the forecasted April—July runoff volume has been equaled or exceeded in 50—70% of the years since 1937. This hydrologic category has a 20% probability of occurrence.

→ **Moderate Dry (70—90% exceedance).**—A year during which the forecasted April—July runoff volume has been equaled or exceeded in 70—90% of the years since 1937. This hydrologic condition has a 20% probability of occurrence.

→ **Dry (90—100% exceedance).**—A year during which the forecasted April—July runoff volume has been equaled or exceeded in 90% or more of the years since 1937. This hydrologic condition has a 10% probability of occurrence.

INFLOWS TO BLUE MESA UNDER HYDROLOGIC CATEGORIES

→ **Wet**— Over 1,123,000 af (≥ 161% of average).

→ **Moderately Wet**— Between 871,000 af and 1,123,000 af (125—161% of average).

→ **Average Wet**— Between 709,000 and 871,000 af (102—125% of average).

→ **Average Dry.**— Between 561,000 and 709,000 af (80—102% of average).

→ **Moderately Dry.**— Between 381,000 and 561,000 (55—80% of average).

→ **Dry.**— Less than 381,000 af (< 55% of average).

SUMMER THROUGH WINTER BASE FLOW RECOMMENDATION FOR THE GUNNISON AND COLORADO RIVERS

Hydrologic Category	Gunnison River at Whitewater	Colorado River at Stateline
Wet; 0—10% Exceedance	1,500—2,500 cfs[2]	3,000—6,000 cfs
Moderately Wet; 10—30% Exceedance	1,050—2,500 cfs	3,000—4,800 cfs
Average Wet; 50—70% Exceedance	≥1,050—2,000 cfs	3,000—4,800 cfs
Average Dry; 50—70% Exceedance	≥1,050— ≥2,000 cfs	2,500—4,000 cfs
Moderately Dry; 70—90% Exceedance	≥750— ≥1,050 cfs	2,500—4,000 cfs
Dry; 90—100% Exceedance	≥750— ≥1,050 cfs	≥1,800 cfs

[2] cfs = cubic feet per second

SPRING PEAK-FLOW RECOMMENDATIONS FOR THE GUNNISON RIVER NEAR GRAND JUNCTION[3]

Hydrologic Category	Expected Occurrence	Flow Target and Duration[4]		Instantaneous Peak Flow (cfs)
		½ Fullbank Discharge Days/Year ≥ 8,070 cfs	Fullbank Discharge Days/Year ≥ 14,350 cfs	
Wet	10%	60—**100**	15—**25**	15,000—23,000[5]
Moderately Wet	20%	40—**60**	10—**20**	14,350-16,000[C]
Average Wet	20%	20—**25**	2—**3**	≥ 14,350[6]
Average Dry	20%	10—**15**	0—**0**	≥ 8,070[d]
Moderately Dry	20%	0—**10**	0—**0**	≥ 2,600[7]
Dry	10%	0—**0**	0—**0**	~ 900—4,000[8]
Long-term Weighted Average[9]		20—**32**	4—**7**	

For example, in a moderately wet year, flows of 14,350 cfs are recommended for 10-20 days.

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[3] This table represents one possible way of achieving the long-term weighted average for sediment transport.
[4] Lower value in each range is for maintenance, higher (bold) value in each range is for improvement.
[5] Instantaneous peak flows within this range have occurred in these hydrologic categories since Blue Mesa Reservoir was closed. The observed instantaneous peaks are desired in the future in conjunction with meeting the flow targets. No specific peak flow with this range is recommended to ensure continued variability among years.
[6] Expected minimum peak flow when recommendations are met; actual peak may exceed the value, ensuring continued variability among years.
[7] Instantaneous peak flow that has occurred since Blue Mesa was closed. Peak flows are expected to equal or exceed this level in years when 8,070 cfs is not reached.
[8] Range of peak flows within this category that have occurred since Blue Mesa Reservoir was closed. Lowest number reflects base flow. Peak flows are expected to continue to occur within this range; no specific flow within this range is recommended, ensuring variability among years.
[9] Weighted values equals days/year x expected occurrence (the sum of all weighted average values equals the long-term weighted average in days/year.

SPRING PEAK-FLOW RECOMMENDATIONS FOR THE COLORADO RIVER NEAR THE COLORADO—UTAH STATE LINE[10]

Hydrologic Category	Expected Occurrence	Flow Target and Duration[11]		Instantaneous Peak Flow (cfs)
		½ Fullbank Discharge **Days/Year ≥ 18,500 cfs**	**Fullbank Discharge** **Days/Year ≥ 35,000 cfs**	
Wet	10%	80—**100**	30—**35**	39,300—69,800[12]
Moderately Wet	20%	50—**65**	15—**18**	35,000—37,500[13]
Average Wet	20%	30—**40**	6—**10**	≥ 35,000[14]
Average Dry	20%	20—**30**	**0**	18,500—26,600[d]
Moderately Dry	20%	0—**10**	**0**	9,970—27,300[15]
Dry	10%	**0**	**0**	5,000—12,100[f]
Long-term Weighted Average[16]		28—**39**	7.2—**9.1**	

[10] This table represents one possible way of achieving the long-term weighted average for sediment transport.
[11] Lower value in each range is for maintenance, higher (bold) value in each range is for improvement.
[12] Instantaneous peak flows within this range have occurred in these hydrologic categories since Blue Mesa Reservoir was closed. These observed instantaneous peaks are desired in the future in conjunction with meeting the flow targets. No specific peak flow is recommended to ensure continued variability among years.
[13] Lower number reflects the expected minimum peak flow when recommendations are met and the upper number reflects peak flows that have occurred since Blue Mesa Reservoir was closed. Peak flow is expected to occur within this range, but no specific value is provided to ensure variability among years.
[14] Expected peak flow when flow recommendations are met. Actual peak may exceed this level ensuring variability among years.
[15] Range of peak flows that have occurred since Blue Mesa Reservoir was closed. Peak flows are expected to continue to fall within this range when 18,500 cfs is not reached. No specific recommendation within this range is made to ensure variability among years.
[16] Weighted values equals days/year x expected occurrence (the sum of all weighted averages equals the long-term weighted average in days/year).

Attachment 3 Aspinall Unit Operations, Consideration of Discretionary vs. Non-Discretionary Actions

LOCATION	OPERATION	BACKGROUND	DISCRETION
A. Blue Mesa Dam	1. End of December target: 7490.0 feet or lower	Based on studies and experience to minimize flooding due to icing upstream near the town of Gunnison. By verbal agreement, Reclamation has usually operated for an end of December icing target of 7490.00 feet elevation since 1980.	Yes
	2. Reservoir target fill: 7517.4 feet by end of runoff season (June-July) and a March 31 target related to flood control.	7517.4 feet is 2 feet from top of spillway gate elevation 7519.4 feet (official full pool). The 2 feet of elevation is a safety factor for controlling the reservoir in case of sudden flood events such as thunderstorms or very high snowmelt inflow.	Yes
	3. Peaking operations: Releases fluctuate between 0 and full powerplant capacity to meet variations in load requirements.	Curecanti Unit, Economic Justification Report, April 1962	Yes
	4. Maintain reservoir elevation to allow hydropower operations	Maintain reservoir above 7393 feet (top of inactive storage)	Yes
	5. Option to draw reservoir down to dead pool if needed.	While unlikely, situations may develop requiring full use of reservoir in a particular year.	Yes

B. Morrow Point Dam	1. Tour boat operations: Attempt to hold reservoir between 7151.0 and 7158.5 feet during the recreation season (May 1-September15) when the tour boat is in operation. When the tour boat is not in operation (September 15-April), the minimum reservoir elevation is 7144.0	Morrow Point Standing Operating Procedure. These elevations are not a strict rule and may be periodically modified to address other needs.	Yes
	2. Drawdown restrictions: To minimize the risk of movement of landslides within the reservoir, the reservoir drawdown rate is limited to a maximum of 3 feet per day at reservoir elevations below 7144 feet For reservoir elevations above 7144, if the reservoir drawdown rate is expected to be greater than 3 feet per day, then visual observations should be made of landslide A.	Morrow Point Standing Operating Procedure	No-However, restrictions include geological observations that may allow modifications in any particular year.
	3. Peaking operations: Flows fluctuate between 0 cfs and full powerplant capacity to meet variations in load requirements	Curecanti Unit, Economic Justification Report, April 1962	Yes
C. Crystal Dam	1. River regulation: Flows relatively uniform. When the powerplant is operating at full capacity, fluctuations could be in the 200 cfs range because the programmable logic control cannot be used at full powerplant capacity.	Curecanti Unit, Economic Justification Report, April 1962 and 1971 Crystal Dam final environmental impact statement.	No River regulation is non-discretionary but some minor fluctuation due to reservoir elevations.
	2. Ramping rates: 500 cfs per day (15%) change for ramping up, and 400 cfs per day (15%) for ramping down.	Ramp rates set for safety of people recreating in the canyon; for fishery considerations; for downstream water users.	Yes
	3. Drawdown restrictions	Dry season drawdown limited to 10 feet in 24 hours and 15 feet in 72 hours. Wet season drawdown limited to 5 feet in 24 hours and 20 feet per week.	No
D. Spring Peak	1. Determined annually by Reclamation with input from the Aspinall	Historic practice to benefit fish and recreation, channel maintenance, and general	Yes

	operations meeting. ▪ Total volume determined from amount of bypass hydrologically necessary. ▪ Normally scheduled in May/June timeframe based on the May 1 forecasts. ▪ Bypass flows consolidated over a shorter timeframe than average.	health of the river. During the January through April period, operations will attempt to reduce the amount of spring bypasses; however, it is recognized that there would be discretion in action alternatives to bypass Aspinall Unit powerplants while providing endangered fish flows.	
E. Black Canyon of the Gunnison and Gunnison Gorge	1. Minimum flow of 300 cfs at the "Below Tunnel" gage under normal conditions; 200 cfs under drought and emergency conditions	State of Colorado 300 cfs junior Gunnison right except in cases of significant drought (as determined by reservoir elevation projections) and Aspinall Unit emergencies.	No
	2. Use of excess water to provide spring peak	For general environmental purposes.	Yes
	3. Avoidance of flow decreases after October 15 when practical; avoidance of flow decreases after April 1 when practical.	Brown trout and rainbow spawn; based on experience and CDOW input	Yes
F. Gunnison River at Delta, Colorado	1. Operate to attempt to prevent flows form exceeding 15,000 cfs at Delta, Colorado	As described in Water Control Manual US Army Corps of Engineers, February 1988	No
	2. Monitor flood conditions at Delta and attempt to reduce damage that can occur below 15,000 cfs	Delta reports that flood damage can begin to occur in the 10,000 to 12,000 cfs range	Yes
G. Redlands Fish ladder	1. Deliver 100 cfs to Redlands fish ladder (June-September)		Yes
	2. Deliver up to 40 cfs to Redlands fish screen (ice-free period)	Diversion canal reduction due to fish screen.	Yes
	3. Provide migration flows of 300 cfs downstream from Redlands fish ladder	Most important during period that fish ladder is operating	Yes
H. Existing Commitments	1. Water sales contracts	Existing water contracts for use of Blue Mesa water	No
	2. Upper Gunnison Subordination Agreement- Allows junior water users within the natural basin of the Gunnison River to	In long-term, could mean up to 60,000 af additional depletions in Upper Gunnison Basin in the future	No

	develop up to a total of 60,000 acre-feet of depletions without interference from the Aspinall Unit.		
	3. Colorado water law and the Law of the River		No
	4. 1975 Taylor Park-Aspinall Unit exchange agreement		No.
	5. Power Contracts	CRSP power contracts are not "unit specific" but apply to integrated power facilities**.**	No discretion on following contracts; however, flexibility within contracts to address changing hydrologic conditions and compliance with other laws.
	6. Meet power system requirements	NERC and WECC reliability requirements (i.e. reserve voltage control, etc.)	No
I. Dallas Creek and Dolores Project Biological Opinions	1. Offset impacts of the depletions from the Dallas Creek and Dolores Projects on endangered fish	Opinions call for upstream Reclamation reservoir to offset the impacts	No

ASPINALL UNIT HYDRAULIC CAPACITIES-no discretion

Capacities (acre-feet)	Blue Mesa	Morrow Point	Crystal
Dead storage	111,200	165	7,700
Inactive storage	81,070	74,905	4,650
Active storage	748,430	42,120	12,890
Live storage*	829,500	117,025	17,540
Total storage	940,700	117,190	25,240
Outlet capacities (cfs)			
Powerplants (max)	2,600-3,400	5,000	2,150
Powerplant bypass	4,000-5,100	1,500	1,900-2,200
Combined powerplant and bypass(max)	6,100	6,500	4,350
Spillway	34,000	41,000	41,350

*-Live storage is the combination of the active and inactive storage. It represents storage that physically can be released from the reservoir.

-Crystal powerplant capacity may be adjusted following testing-the new capacity may affect reservoir targets.

-Blue Mesa Reservoir shares one penstock for both river outlet and powerplant releases; the combined releases of these two are constrained to about 6,100 cfs.

-The hydraulic capacities shown in the table assume full reservoir conditions. At lower elevations, the hydraulic capacity would be less. Also system efficiencies may affect the hydraulic capacity.

-Full capacity may not always be available due to scheduled maintenance**,** equipment malfunction, or power system reserve requirements.

-There are no specific recreation or fishery pools in the reservoirs.

Attachment 4--Number of Cross Sections reaching ½ bankfull or bankfull levels at various Gunnison River flow levels; from Pitlick et al. data (1999)

Flow	No. X-sections ½ bankfull	Flow	No. X-sections bankfull
4660	1	7352	1
4728	2	8838	2
4895	3	9315	3
4951	4	10260	4
5117	5	10719	5
5144	6	10738	6
5316	7	10952	7
5359	8	11391	8
5576	9	11485	9
5988	10	11741	10
6025	11	11834	11
6031	12	11933	12
6186	13	11944	13
6668	14	11987	14
6836	15	12419	15
6893	16	13039	16
6900	17	13069	17
6930	18	13101	18
7017	19	13202	19
7037	20	13250	20
7200	21	13310	21
7285	22	13324	22
7404	23	13387	23
7711	24	13629	24
7906	25	13832	25
8044	26	14283	26
8047	27	14311	27
8098	28	14338	28
8107	29	14347	29
8303	30	14366	30
8393	31	14495	31
8440	32	14573	32
8571	33	14901	33
8719	34	15582	34
8787	35	15948	35
8847	36	15984	36
8997	37	16041	37
9157	38	16110	38
9285	39	16940	39
9345	40	17162	40
9474	41	17806	41
9492	42	18132	42
9580	43	18534	43
9823	44	19282	44
10229	45	21976	45
11081	46	22140	46
11236	47	22959	47
11532	48	23179	48
11674	49	23297	49
11717	50	23418	50
11860	51	24846	51
12033	52	24699	52
12658	53	25565	53
12695	54	28719	54

Attachment 5. Summary of water quality data

5.1 Data collected by the USGS from 1968-1998 for the Gunnison River at the Whitewater gage (from Butler 2000)

Parameter	Number of samples	Period collected	Median	Maximum	Minimum	90th percentile concentration
Oxygen, mg/L	244	70-98	9.2	13.7	6.4	11.6
pH	335	68-98	8.1	8.9	6.7	8.4
Fecal coli-form, counts/100 ml	108	76-95	58	1,100	1	360
Unionized ammonia, mg/L	142	80-98	.001	.022	0	.004
Unionized ammonia, total mg/L	83	78-92	.001	.011	0	.005
Nitrite mg/L	100	81-98	.01	.06	<.01	.02
Nitrite + nitrate, mg/L	200	70-98	.78	2.9	.1	1.6
Chloride, mg/L	337	68-98	8.2	58	1.9	16
Sulfate, mg/L	337	68-98	310	950	60	670
Boron microgram/L	33	68-71 91-92	50	300	0	140
Hardness, mg/L	337	68-98	360	875	107	608
Arsenic, total Microgram/L	66	75-91	1	7	<1	3
Arsenic Microgram/L	66	75-91	1	7	<1	3
Cadmium Microgram/L	65	75-91	<1	10	<1	2
Chromium Microgram/L	65	75-91	<1	10	<1	2
Copper Microgram/L	65	75-91	2	23	<2	7

Iron, total Microgram/L	28	75-82	955	8,800	190	3,100
Iron, Microgram/L	170	71-98	13	1,500	<3	60
Lead Microgram/L	66	75-91	1	71	<1	9
Manganese total, Microgram/L	28	75-82	60	260	30	190
Manganese Microgram/L	170	71-98	14	140	<10	40
Mercury, dissolved Microgram/L	64	75-91	<.1	.3	<.1	.1
Nickel, Microgram/L	62	75-91	1	28	<1	4
Selenium, Microgram/L	132	75-98	5	25	<1	10
Selenium, total Microgram/L	28	75-82	10	21	4	19
Silver, Microgram/L	70	75-91	<1	1	<1	<1
Zinc, Microgram/L	66	75-91	7	82	<3	21

Table 5.2. Parameters exceeding the 85th percentile or had occasional exceedances of State Standards.

[Chemical constituents are dissolved unless otherwise noted; ammonia for USGS data at station 09144250 is combined dissolved and total data; *, geometric mean concentration for fecal coliform data; number of exceedances, number of samples that were equal to or greater than the numeric standard; col/100 mL, colonies per 100 milliliters; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; --, no data]

Parameter	State standard	USGS Data: Number of samples	USGS Data: 85th percentile	USGS Data: Number of exceedances	STORET Data: Number of samples	STORET Data: 85th percentile	STORET Data: Number of exceedances
Gunnison River at Delta (USGS station 09144250, STORET station 000056)							
Fecal coliform (col/100 mL)	200	11	*51	2	146	*37	31
Un-ionized ammonia (mg/L)	.02	13	.002	0	127	.007	2
Sulfate (mg/L)	250	20	300	8	144	240	20
Iron, total (µg/L)	1,000	11	4,200	5	0	--	--
Selenium (µg/L)	5	20	5.5	7	[1]56	3	4
Gunnison River near Grand Junction (USGS station 09152500, STORET station 000054)							
Fecal coliform (col/100 mL)	200	108	*34	24	176	*76	71
Un-ionized ammonia (mg/L)	.02	142	.003	1	144	.014	15
Sulfate (mg/L)	480	337	598	84	62	650	18
Cadmium (µg/L)	3.1	65	2	3	0	--	--
Iron, total (µg/L)	2,300	28	1,900	4	0	--	--
Lead (µg/L)	24	65	6	2	0	--	--
Manganese (µg/L)	50	170	33	9	0	--	--
Selenium (µg/L)	[2]8	132	9	35	[1]58	12	21
Colorado River near Fruita (STORET station 000049)							
Fecal coliform (col/100 mL)	200	0	--	--	68	*632	54
Un-ionized ammonia (mg/L)	.06	0	--	--	46	.017	1
Selenium, total (µg/L)	17	0	--	--	48	9	0
Colorado River at Loma (STORET station 000050)							
Fecal coliform (col/100 mL)	200	0	--	--	413	*178	228
Un-ionized ammonia (mg/L)	.06	0	--	--	421	.011	4
Cadmium (µg/L)	2.9	0	--	--	91	<0.3	0
Iron, total (µg/L)	2,600	0	--	--	6	6,700	2
Selenium, dissolved (µg/L)	17	0	--	--	37	6.9	0
Selenium, total (µg/L)	17	0	--	--	120	11	7
Colorado River near Colorado-Utah State line (USGS station 09163500)							
Fecal coliform (col/100 mL)	200	121	*70	40	0	--	--
Un-ionized ammonia (mg/L)	.06	151	.003	0	0	--	--
Cadmium (µg/L)	2.9	68	3	11	0	--	--
Iron, total (µg/L)	2,600	27	5,900	11	0	--	--
Mercury (µg/L)	.01	67	.1	[3]13	0	--	--
Selenium (µg/L)	17	145	8	1	0	--	--

[1] Data are for total selenium.

[2] Standard is a temporary modification, which expires in August 2002. Eighty-one USGS samples and 32 STORET samples were equal to or greater than 5 µg/L.

[3] Number of samples with mercury concentrations equal to or greater than the 0.1-µg/L minimum reporting level.

Attachment 6--Temperature and Selenium Data: Gunnison River at Whitewater (from Butler 2000 and others)

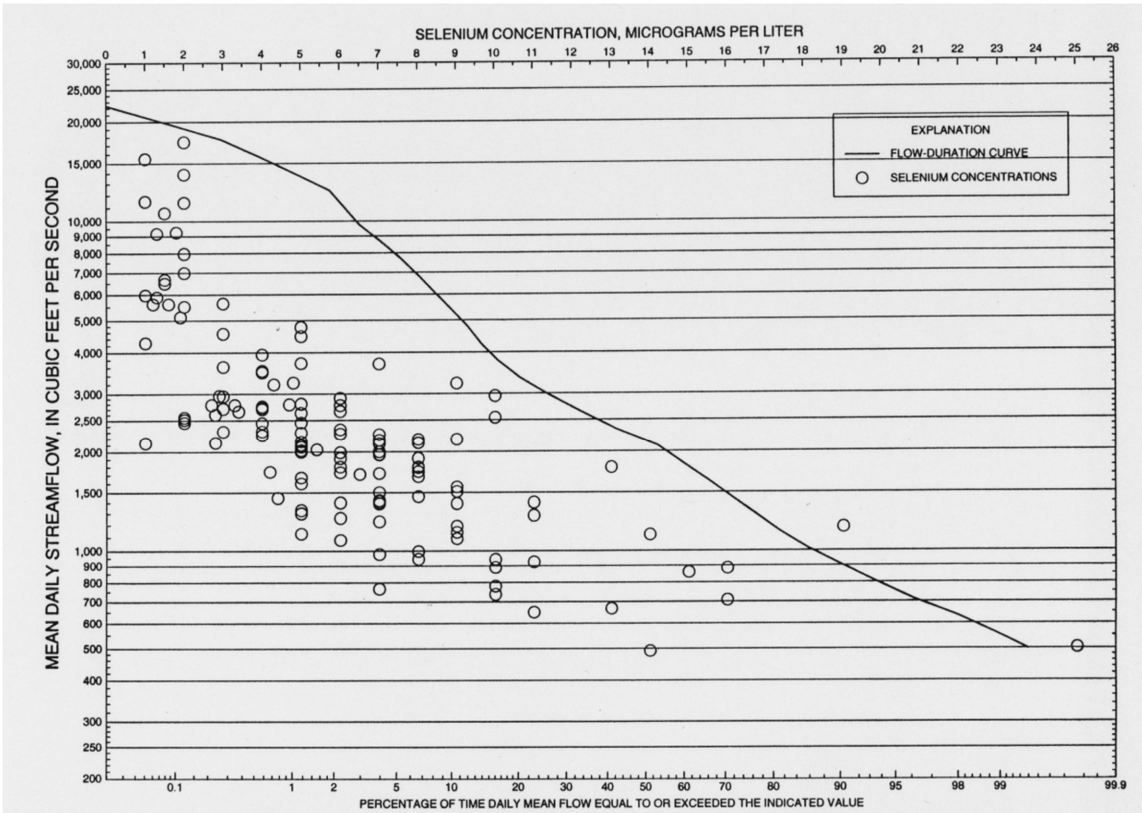

Figure 2. Flow-duration curve and dissolved-selenium concentrations in samples collected by the U.S. Geological Survey since 1976 for station 09152500, Gunnison River near Grand Junction. (132 samples).

Environmental baseline: Average monthly selenium concentration, ppb, Gunnison River at Whitewater.															
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg	Max	Min
1975	17.1	15.5	9.7	5.2	3.7	4.3	6.2	9.8	10.0	10.4	11.1	10.2	9.4	17.1	3.7
1976	11.1	9.6	9.9	7.5	4.9	6.5	9.2	14.1	12.1	11.5	14.3	15.9	10.6	15.9	4.9
1977	13.8	13.7	12.2	12.6	12.2	14.6	16.0	18.4	19.1	17.6	16.8	17.0	15.3	19.1	12.2
1978	15.1	14.7	11.7	4.3	3.3	3.7	7.0	11.5	12.0	17.7	15.2	11.9	10.7	17.7	3.3
1979	7.8	5.3	4.8	3.8	2.7	3.3	6.4	9.4	9.8	10.4	10.4	9.9	7.0	10.4	2.7
1980	9.8	5.3	5.8	4.0	2.4	3.1	7.2	10.9	12.2	15.1	11.0	9.1	8.0	15.1	2.4
1981	11.0	16.8	10.1	7.6	7.5	9.4	11.8	14.0	12.3	10.8	12.7	13.9	11.5	16.8	7.5
1982	8.9	7.5	7.3	4.1	2.7	3.6	6.1	7.5	6.6	6.7	6.8	6.2	6.2	8.9	2.7
1983	7.9	7.4	5.6	4.4	2.4	2.1	3.1	5.8	7.4	6.9	7.0	5.8	5.5	7.9	2.1
1984	4.9	4.6	4.2	3.1	1.9	2.0	3.3	5.8	6.6	6.0	5.8	5.0	4.4	6.6	1.9
1985	4.8	4.8	5.0	2.5	2.0	2.3	4.6	8.4	6.9	6.3	6.2	5.5	4.9	8.4	2.0
1986	5.0	5.7	3.3	2.5	2.2	2.8	3.6	6.9	6.0	5.4	5.2	4.6	4.4	6.9	2.2
1987	5.6	5.3	4.7	2.9	2.4	2.9	6.2	6.6	6.4	7.6	8.1	7.4	5.5	8.1	2.4
1988	8.2	6.7	6.9	4.2	4.6	5.5	7.2	11.1	9.6	10.5	11.6	11.2	8.1	11.6	4.2
1989	8.7	6.7	5.1	3.9	5.2	6.0	7.2	9.9	9.6	10.3	11.1	10.7	7.9	11.1	3.9
1990	10.6	10.0	8.7	7.3	5.3	6.0	7.4	11.1	10.0	9.1	9.5	8.6	8.6	11.1	5.3
1991	8.6	8.2	7.0	4.7	2.8	3.3	5.7	7.0	6.5	6.9	7.1	6.2	6.2	8.6	2.8
1992	7.7	7.8	6.4	3.1	3.0	4.1	5.3	6.8	7.0	6.7	7.0	7.3	6.0	7.8	3.0
1993	7.8	6.1	3.4	2.5	1.6	2.0	4.1	5.6	5.7	5.4	5.7	5.7	4.6	7.8	1.6
1994	6.6	6.3	5.1	4.1	3.1	3.9	6.2	8.2	7.5	6.9	7.2	6.7	6.0	8.2	3.1
1995	7.3	6.9	3.5	2.7	1.8	1.6	2.0	4.6	5.2	5.1	4.8	4.4	4.2	7.3	1.6
1996	5.5	4.0	3.2	2.6	2.2	3.3	5.4	6.9	6.1	6.4	6.0	5.3	4.7	6.9	2.2
1997	4.0	3.5	3.2	2.6	1.8	2.0	3.7	5.0	4.6	4.6	4.7	4.4	3.7	5.0	1.8
1998	5.6	5.3	4.1	2.8	1.9	3.6	4.7	6.8	6.3	6.1	6.2	5.9	4.9	6.8	1.9
1999	6.9	6.2	5.0	5.5	3.0	2.8	4.1	4.4	4.9	5.3	5.4	5.0	4.9	6.9	2.8
2000	5.9	5.2	4.6	3.2	3.5	4.9	5.7	8.4	7.5	7.0	8.1	7.8	6.0	8.4	3.2
2001	7.2	7.3	5.8	4.8	3.1	4.4	5.3	6.7	6.3	6.8	7.4	6.8	6.0	7.4	3.1
2002	7.2	7.3	7.0	6.1	7.0	9.4	10.6	10.4	9.1	8.9	10.3	10.7	8.7	10.7	6.1
2003	9.9	9.0	7.7	6.1	3.6	5.8	11.7	11.1	8.8	9.7	10.5	10.6	8.7	11.7	3.6
2004	9.4	8.7	6.4	3.9	3.6	5.3	6.4	9.6	8.2	8.1	9.5	9.3	7.4	9.6	3.6
2005	6.6	4.6	4.6	2.6	1.9	2.7	4.7	6.8	6.7	6.1	6.9	7.4	5.1	7.4	1.9

Proposed action: Average monthly selenium concentration, ppb, Gunnison River at Whitewater.															
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg	Max	Min
1975	14.1	12.5	11.6	6.1	4.2	4.2	6.7	10.0	10.7	11.1	12.1	11.2	9.5	14.1	4.2
1976	12.0	10.4	10.4	7.8	4.1	7.4	11.5	15.2	14.4	13.1	17.3	17.0	11.7	17.3	4.1
1977	15.3	14.0	13.2	12.7	12.5	13.2	14.3	18.1	19.1	17.6	17.1	17.0	15.4	19.1	12.5
1978	15.2	13.9	11.7	4.7	3.3	3.4	9.2	13.9	13.8	15.5	14.0	12.5	10.9	15.5	3.3
1979	11.5	5.5	6.3	4.1	2.8	2.9	7.2	10.5	13.0	13.1	13.0	12.7	8.5	13.1	2.8
1980	11.3	5.9	6.9	4.5	2.4	3.2	7.3	10.2	12.5	14.3	12.2	10.2	8.4	14.3	2.4
1981	12.1	12.3	10.6	7.9	7.7	9.3	11.7	14.2	12.6	11.0	13.0	14.2	11.4	14.2	7.7
1982	10.9	8.8	8.5	4.3	2.7	3.7	6.5	8.0	7.0	7.1	7.1	6.6	6.8	10.9	2.7
1983	8.5	7.9	5.9	4.5	2.5	2.1	3.2	6.0	7.5	7.1	7.2	6.0	5.7	8.5	2.1
1984	5.0	4.7	4.4	3.1	1.9	2.0	3.5	6.1	6.8	6.1	5.9	5.1	4.5	6.8	1.9
1985	4.9	5.1	5.1	2.6	2.0	2.4	5.0	8.3	7.1	6.4	6.3	5.6	5.1	8.3	2.0
1986	5.2	6.1	3.4	2.7	2.2	2.7	4.4	7.1	6.2	5.5	5.4	4.8	4.6	7.1	2.2
1987	5.9	5.6	4.9	2.9	2.4	3.1	6.3	6.9	6.6	7.9	8.5	7.7	5.7	8.5	2.4
1988	8.8	7.3	7.0	4.4	4.4	5.7	8.0	10.7	10.4	11.6	12.2	12.0	8.5	12.2	4.4
1989	10.3	7.7	5.6	4.0	4.7	6.3	7.8	10.4	10.7	10.6	11.4	11.0	8.4	11.4	4.0
1990	10.7	10.0	8.9	7.4	5.4	6.6	8.4	10.4	10.3	9.3	11.2	11.1	9.2	11.2	5.4
1991	10.3	9.5	8.2	4.8	2.8	3.3	5.9	7.4	6.8	7.2	7.5	6.5	6.7	10.3	2.8
1992	7.9	7.5	6.7	3.3	3.0	4.3	5.4	7.5	7.6	7.1	7.6	8.2	6.3	8.2	3.0
1993	8.2	6.6	3.5	2.8	1.7	1.9	4.2	5.8	5.9	5.6	5.9	5.9	4.8	8.2	1.7
1994	6.8	6.5	5.2	4.2	2.9	4.6	6.4	9.1	8.2	7.5	7.9	7.4	6.4	9.1	2.9
1995	8.0	7.6	3.7	3.0	1.9	1.6	2.0	4.8	5.3	5.2	4.9	4.6	4.4	8.0	1.6
1996	5.6	4.2	3.4	2.9	2.1	3.6	5.6	7.8	6.7	6.9	6.6	5.8	5.1	7.8	2.1
1997	4.0	3.6	3.4	2.6	1.8	2.0	4.2	5.3	4.7	4.7	4.8	4.5	3.8	5.3	1.8
1998	5.8	5.4	4.2	2.9	2.0	3.6	4.8	7.0	6.5	6.2	6.3	6.0	5.1	7.0	2.0
1999	7.5	6.7	5.4	5.6	2.7	2.9	4.5	4.8	5.0	5.6	5.8	5.3	5.2	7.5	2.7
2000	6.2	5.5	4.9	3.3	3.1	5.1	6.8	9.0	8.3	7.8	8.9	9.5	6.5	9.5	3.1
2001	9.2	8.6	7.1	5.0	2.7	5.2	5.5	7.6	7.0	7.6	8.5	8.1	6.8	9.2	2.7
2002	8.0	8.1	7.5	6.4	7.2	8.2	9.1	10.5	9.4	9.1	10.6	10.7	8.7	10.7	6.4
2003	9.7	8.7	7.7	6.2	3.5	5.7	8.1	8.9	9.1	9.9	10.8	10.7	8.2	10.8	3.5
2004	9.4	8.6	6.6	4.0	3.4	6.3	8.1	8.9	8.4	8.3	9.7	9.5	7.6	9.7	3.4
2005	8.1	7.5	6.5	2.9	2.0	2.7	4.8	7.1	7.0	6.3	7.1	7.7	5.8	8.1	2.0

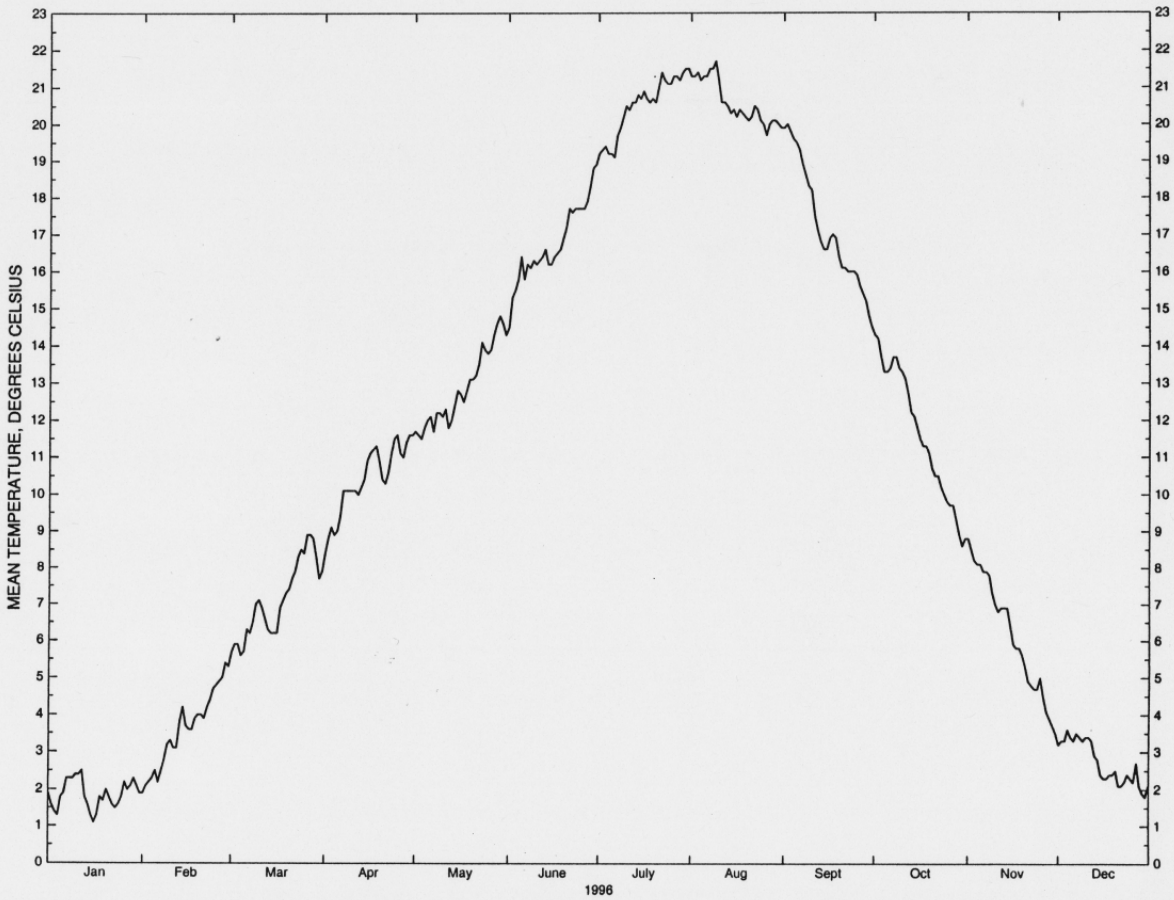

Figure 4. Mean daily water temperature at station 09152500, Gunnison River near Grand Junction, water years 1976-98.

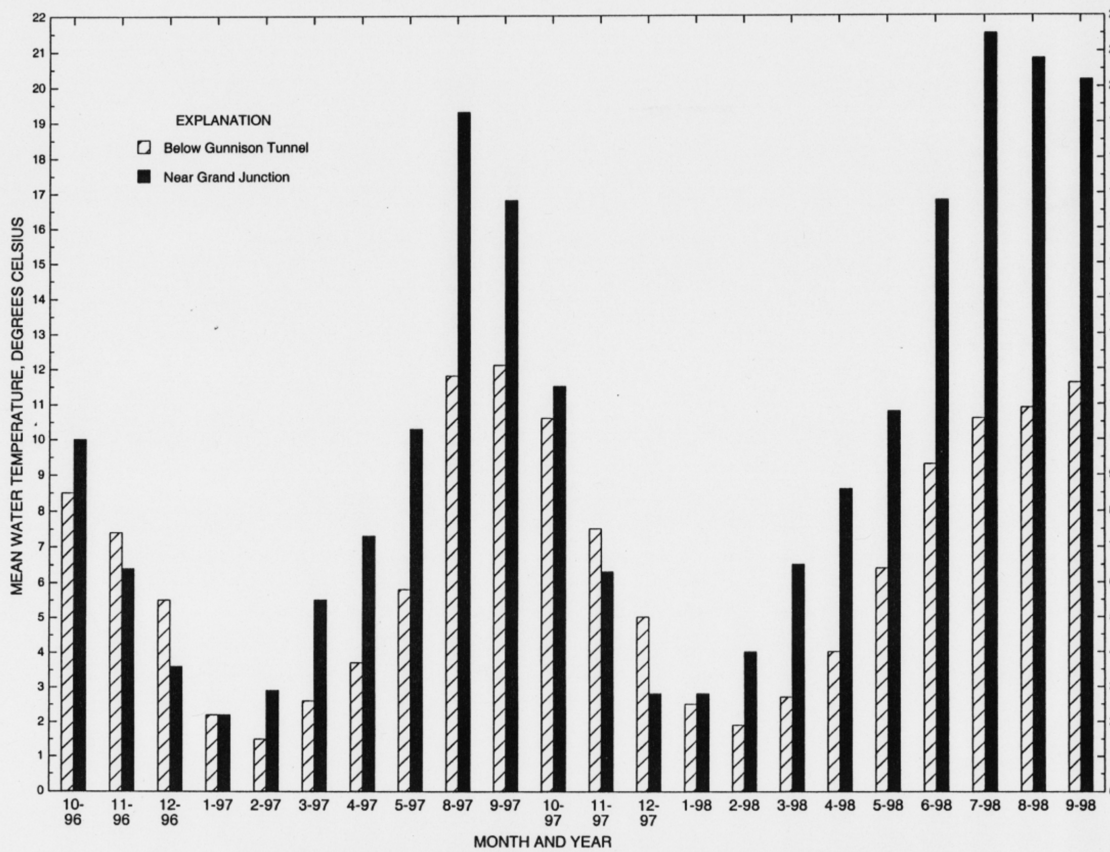

Figure 5. Mean water temperature, by month, Gunnison River below Gunnison Tunnel and Gunnison River near Grand Junction, water years 1997-98. Means computed only using days with values at both sites.

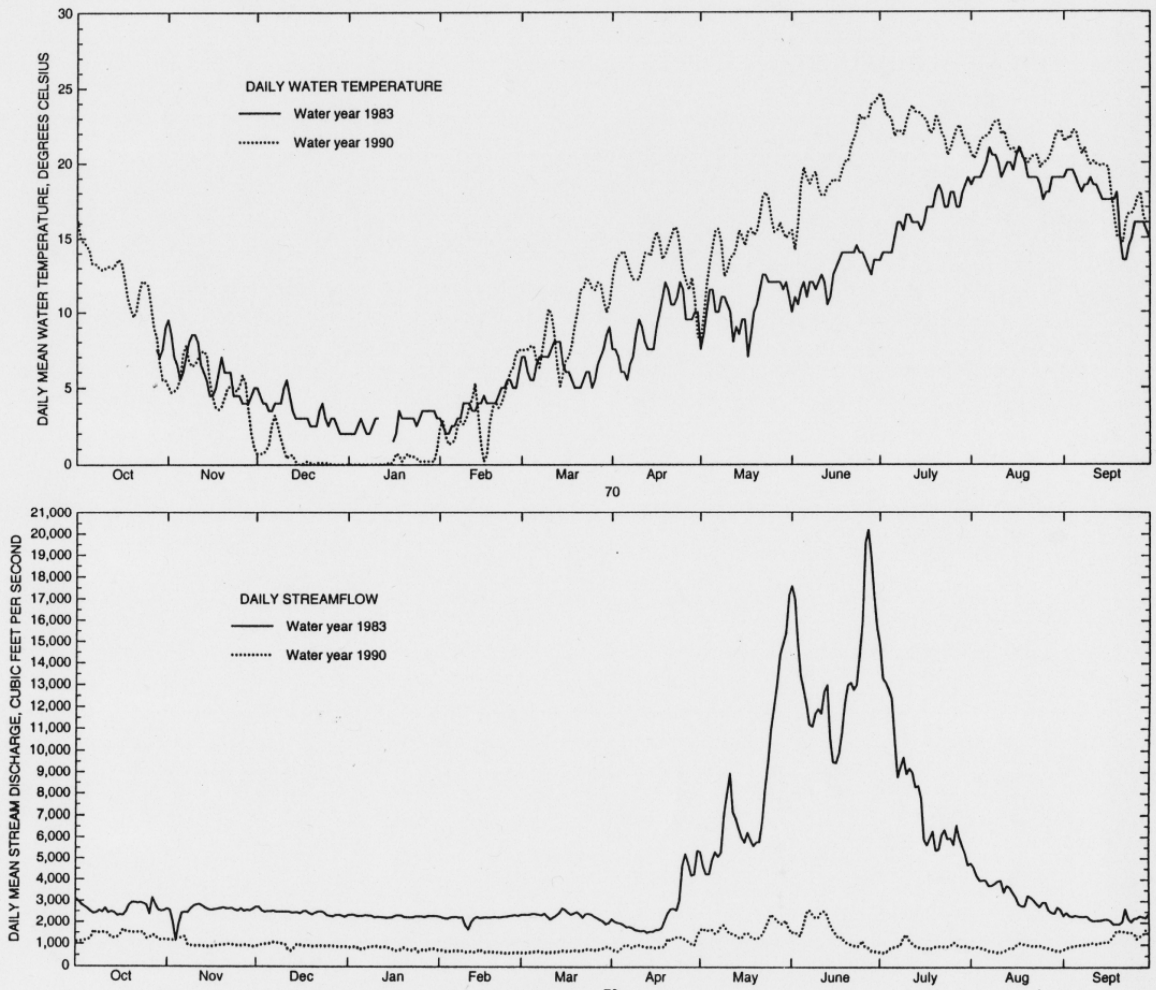

Figure 7. Daily mean stream temperature and streamflow at gaging station 09152500, Gunnison River near Grand Junction, water years 1983 and 1990.

Attachment 7 Recovery Goals [17](from Reclamation 2005)

Recovery Goals-Colorado Pikeminnow (Fish and Wildlife Service 2002c)

Downlisting can be considered if, over a 5-year period:

- A genetically and demographically viable, self-sustaining population is maintained in the Green River subbasin such that (a) the trends in separate adult point estimates for the middle Green River and the lower Green River do not decline significantly, and (b) mean estimated recruitment of age-6 naturally produced fish equals or exceeds mean annual adult mortality for the Green River subbasin, and (c) each population point estimate for the Green River subbasin exceeds 2,600 adults (2,600 is the estimated minimum viable population needed to ensure long-term genetic and demographic viability); and
- A self-sustaining population of at least 700 adults (numbers based on inferences about carrying capacity) is maintained in the upper Colorado River subbasin such that (a) the trend in adult point estimates does not decline significantly, and (b) mean estimated recruitment of age-6 naturally produced fish equals or exceeds mean annual adult mortality; and
- A target number of 1,000 age 5+ fish is established through augmentation and/or natural reproduction in the San Juan River subbasin; and
- Certain site-specific management tasks to minimize or remove threats have been identified, developed, and implemented.

Delisting can be considered if, over a 7-year period beyond downlisting:

- A genetically and demographically viable, self-sustaining population is maintained in the Green River subbasin such that (a) the trends in separate adult point estimates for the middle Green River and the lower Green River do not decline significantly, and (b) mean estimated recruitment of age-6 naturally produced fish equals or exceeds mean annual adult mortality for the Green River subbasin, and (c) each population point estimate for the Green River subbasin exceeds 2,600 adults; and
- Either the upper Colorado River subbasin self-sustaining population exceeds 1,000 adults or the upper Colorado River subbasin self-sustaining population exceeds 700 adults and the San Juan River subbasin population is self-sustaining and exceeds 800 adults (numbers based on inferences about carrying capacity such that or each population (a) the trend in adult point estimated does not decline significantly, and (b) mean estimated recruitment of age-6 naturally produced fish equals or exceeds mean annual adult mortality; and
- Certain site-specific management tasks to minimize or remove threats have been finalized and implemented, and necessary levels of protection are attained.

Recovery Goals-Razorback Sucker (Fish and Wildlife Service 2002d)
Downlisting can be considered if, over a 5-year period:

- Genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and either in the upper Colorado River

[17] Recovery goals are being updated.

subbasin or the San Juan River subbasin such that (a) the trend in adult (age 4+) point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age -3 naturally produced fish equals or exceeds mean annual adult mortality for each of the tow populations, and)c) each point estimate for each of the two populations exceeds 5,800 adults (5,800 is the estimated minimum viable population needed to ensure long-term genetic and demographic viability); and

- A genetic refuge is maintained in Lake Mohave of the lower basin recovery unit; and
- Certain site-specific management tasks to minimize or remove threats have been identified, developed, and implemented.

Delisting can be considered if, over a 3-year period beyond downlisting:

- Genetically and demographically viable, self-sustaining populations are maintained in the Green River subbasin and either in the upper Colorado River subbasin or the San Juan River subbasin such that (a) the trend in adult point estimates for each of the two populations does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each of the two populations, and (c) each point estimate for each of the two populations exceeds 5,800 adults; and
- A genetic refuge is maintained in Lake Mohave; and
- Two genetically and demographically viable, self-sustaining populations are maintained in the lower basin recovery unit such that (a) the trend in adult point estimates for each population does not decline significantly, and (b) mean estimated recruitment of age-3 naturally produced fish equals or exceed mean annual adult mortality for each population, and (c) each point estimate for each population exceeds 5,800 adults; and
- Certain site-specific management tasks to minimize or remove threats have been finalized and implemented, and necessary levels of protection are maintained.

Recovery Goals-Humpback Chub (Fish and Wildlife Service 2002e)

Downlisting can be considered if, over a 5-year period:

- The trend in adult (age 4+) point estimates for each of the six extant populations does not decline significantly; and
- Mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each of the six extant populations; and
- Two genetically and demographically viable, self-sustaining core populations are maintained, such that each point estimate for each core population exceeds 2,100 adults (2,100 is the estimated minimum viable population needed to ensure long-term genetic and demographic viability); and
- Certain site-specific management tasks to minimize or remove threats have been identified, developed, and implemented.

Delisting can be considered if, over a 3-year period beyond downlisting:

- The trend in adult point estimates for each of the six extant populations does not decline significantly; and
- Mean estimated recruitment of age-3 naturally produced fish equals or exceeds mean annual adult mortality for each of the six extant populations; and

- Three genetically and demographically viable, self-sustaining core populations are maintained, such that each point estimate for each core population exceeds 2,100 adults; and
- Certain site-specific management tasks to minimize or remove threats have been finalized and implemented, and necessary levels of protection are attained.

Management actions identified in the recovery goals for bonytail (Fish and Wildlife Service 2002) to minimize or remove threats to the species include:

- Provide and legally protect habitat (including flow regimes necessary to restore and maintain required environmental conditions) necessary to provide adequate habitat and sufficient range for all life stages to support recovered populations;
- Provide passage over barriers within occupied habitat to allow unimpeded movement and, potentially, range expansion;
- Investigate options for providing appropriate water temperatures in the Gunnison River;
- Minimize entrainment of subadults and adults and diversion/take-out structures;
- Investigate habitat requirement s for all life stages and provide those habitats;
- Ensure adequate protection from overutilization;
- Ensure adequate protection from diseases and parasites; regulate nonnative fish releases and escapement in the main river, floodplain, and tributaries;
- Control problematic nonnative fishes as needed;
- Minimize the risk of increased hybridization among *Gila* spp.;
- Minimize the risk of hazardous-materials spills in critical habitat; and
- Remediate water-quality problems.

Attachment 8--Additional hydrology data

8.1 Summary of peaks (cfs) under baseline and proposed alternative, Whitewater gage.

Year	Baseline Peak	Proposed Action Peak	Year	Baseline Peak	Proposed Action Peak
1975	8927	12296	1991	8412	8593
1976	5130	8386	1992	6063	8583
1977	1581	1636	1993	20492	21040
1978	10678	11364	1994	4919	7755
1979	15164	16261	1995	19346	19125
1980	13884	16326	1996	7860	12412
1981	3773	3771	1997	11996	14350
1982	9140	11023	1998	9877	9158
1983	20640	20350	1999	6793	7783
1984	20782	20941	2000	4817	7840
1985	15186	15503	2001	3487	7439
1986	10357	13727	2002	1153	1170
1987	9241	10191	2003	5312	7033
1988	3436	5814	2004	3413	5207
1989	2465	5243	2005	13574	11372
1990	2574	2566			

8.2 Comparison of flow duration under baseline and proposed action at Whitewater gage.

Year	Days >6,000 cfs		Days>7,000 cfs		Days>8,000 cfs		Days>10,000 cfs		Days>14,000 cfs	
	Baseline	Plan	Baseline	Plan	Baseline	Plan	Baseline	Plan	Baseline	Plan
1975	32	37	26	33	8	24	0	6	0	0
1976	0	11	0	8	0	2	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0
1978	27	42	15	36	11	25	2	9	0	0
1979	53	57	35	44	27	34	16	22	4	5
1980	61	55	50	45	42	36	13	17	0	3
1981	0	0	0	0	0	0	0	0	0	0
1982	26	32	16	23	9	15	0	6	0	0
1983	75	71	59	67	53	54	44	44	13	17
1984	85	87	78	77	67	67	57	56	31	30
1985	81	81	75	73	62	57	29	31	4	6
1986	63	59	40	44	25	28	5	17	0	0
1987	42	43	34	34	18	17	0	1	0	0
1988	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0
1991	9	13	4	9	1	2	0	0	0	0
1992	1	5	0	3	0	1	0	0	0	0
1993	75	64	66	58	49	50	27	35	17	18
1994	0	7	0	4	0	0	0	0	0	0
1995	93	82	76	74	73	72	61	69	28	29
1996	10	23	7	20	0	9	0	4	0	0
1997	67	64	53	50	47	37	12	15	0	2
1998	30	29	18	14	7	6	0	0	0	0
1999	7	14	0	11	0	0	0	0	0	0
2000	0	7	0	3	0	0	0	0	0	0
2001	0	7	0	3	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0
2003	0	3	0	1	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0
2005	31	26	19	17	12	10	7	5	0	0
Average	28.0	29.6	21.6	24.2	16.5	17.6	8.8	10.9	3.1	3.5

8.3 Days reaching various flow levels important to backwater/flooded bottomland habitat.

Year	Days >5,000 cfs*		Days >8,000 cfs*		Days >10,000 cfs*		Days >14,000 cfs*	
	Baseline	Plan	Baseline	Plan	Baseline	Plan	Baseline	Plan
1975	41	39	85	24	0	6	0	0
1976	2	13	0	2	0	0	0	0
1977	0	0	0	0	0	0	0	0
1978	44	44	118	25	2	9	0	0
1979	65	75	27	34	16	22	4	5
1980	67	67	42	36	13	17	0	3
1981	0	0	0	0	0	0	0	0
1982	38	43	9	15	0	6	0	0
1983	92	91	53	54	44	44	13	17
1984	94	95	66	67	57	56	31	30
1985	84	82	62	57	29	31	4	6
1986	101	77	25	28	5	17	0	0
1987	60	59	18	17	1	1	0	0
1988	0	3	0	0	0	0	0	0
1989	0	2	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0
1991	26	24	1	2	0	0	0	0
1992	2	8	0	1	0	0	0	0
1993	80	73	49	50	27	35	17	18
1994	0	11	0	0	0	0	0	0
1995	94	88	73	72	61	69	28	29
1996	28	27	0	9	0	4	0	0
1997	76	75	47	37	12	15	0	2
1998	40	40	7	6	0	0	0	0
1999	12	17	0	0	0	0	0	0
2000	0	10	0	0	0	0	0	0
2001	0	10	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0
2003	2	9	0	0	0	0	0	0
2004	0	1	0	0	0	0	0	0
2005	48	41	12	10	7	5	0	0
Avg. days/yr	35.4	36.3	16.5	17.6	8.8	10.9	3.1	3.5
Percentage of years	68	87	48	61	32	48	10	26

8.4 Number of cross-sections reaching ½ bankfull or bankfull during May-July

Year	Baseline-No. cross-sections reaching ½ bankfull	Proposed Action-No. cross-sections reaching ½ bankfull	Baseline-No. cross-sections reaching bankfull	Proposed Action-No. cross-sections reaching bankfull
1975	36	52	2	14
1976	5	30	0	1
1977	0	0	0	0
1978	45	47	4	7
1979	54	54	33	38
1980	54	54	25	38
1981	0	0	0	0
1982	37	46	2	7
1983	54	54	44	44
1984	54	54	44	44
1985	54	54	33	33
1986	45	54	4	24
1987	38	44	2	3
1988	0	9	0	0
1989	0	6	0	0
1990	0	0	0	0
1991	31	33	1	1
1992	11	33	0	1
1993	54	54	44	44
1994	3	24	0	1
1995	54	54	15	43
1996	24	52	1	14
1997	51	54	14	31
1998	44	38	3	2
1999	0	24	0	1
2000	2	24	0	0
2001	0	23	0	0
2002	0	0	0	0
2003	6	19	0	0
2004	0	6	0	0
2005	54	47	23	7
	Avg 26	Avg 37	Avg 9	Avg 13
Percentage of years ½ or bankfull flows reached	71%	87%	55%	68%

Attachment 8.5. Comparison of Baseline and Proposed Operation, number of days in the year above given flow, presented according to year category.

Year	Water category	**Base >5000 cfs**	**Action >5000 cfs**	Base >7000 cfs	Action >7000 cfs	**Base >8000 cfs**	**Action >8000 cfs**	Base >10000 cfs	Action >10000 cfs	**Base >14000 cfs**	**Action >14000 cfs**
1977	Dry	**0**	**0**	0	0	**0**	**0**	0	0	**0**	**0**
1981	Dry	**0**	**0**	0	0	**0**	**0**	0	0	**0**	**0**
2002	Dry	**0**	**0**	0	0	**0**	**0**	0	0	**0**	**0**
1990	Dry	**0**	**0**	0	0	**0**	**0**	0	0	**0**	**0**
1988	ModDry	**0**	**3**	0	0	**0**	**0**	0	0	**0**	**0**
1989	ModDry	**0**	**2**	0	0	**0**	**0**	0	0	**0**	**0**
1992	ModDry	**2**	**8**	0	3	**0**	**1**	0	0	**0**	**0**
1994	ModDry	**0**	**11**	0	4	**0**	**0**	0	0	**0**	**0**
2000	ModDry	**0**	**10**	0	3	**0**	**0**	0	0	**0**	**0**
2001	ModDry	**0**	**10**	0	3	**0**	**0**	0	0	**0**	**0**
2003	ModDry	**2**	**9**	0	1	**0**	**0**	0	0	**0**	**0**
2004	ModDry	**0**	**1**	0	0	**0**	**0**	0	0	**0**	**0**
1976	AvgDry	**2**	**13**	0	8	**0**	**2**	0	0	**0**	**0**
1987	AvgDry	**60**	**59**	34	34	**18**	**17**	0	1	**0**	**0**
1991	AvgDry	**26**	**24**	4	9	**1**	**2**	0	0	**0**	**0**
1998	AvgDry	**40**	**40**	18	14	**7**	**6**	0	0	**0**	**0**
1999	AvgDry	**12**	**17**	0	11	**0**	**0**	0	0	**0**	**0**
1982	AvgWet	**38**	**43**	16	23	**9**	**15**	0	6	**0**	**0**
1983	AvgWet	**92**	**91**	59	67	**53**	**54**	44	44	**13**	**17**
1996	AvgWet	**28**	**27**	7	20	**0**	**9**	0	4	**0**	**0**
2005	AvgWet	**48**	**41**	19	17	**12**	**10**	7	5	**0**	**0**
1975	ModWet	**41**	**39**	26	33	**8**	**24**	0	6	**0**	**0**
1978	ModWet	**44**	**44**	15	36	**11**	**25**	2	9	**0**	**0**
1979	ModWet	**65**	**75**	35	44	**27**	**34**	16	22	**4**	**5**
1980	ModWet	**67**	**67**	50	45	**42**	**36**	13	17	**0**	**3**
1985	ModWet	**84**	**82**	75	73	**62**	**57**	29	31	**4**	**6**
1986	ModWet	**101**	**77**	40	44	**25**	**28**	5	17	**0**	**0**
1993	ModWet	**80**	**73**	66	58	**49**	**50**	27	35	**17**	**18**
1995	ModWet	**94**	**88**	76	74	**73**	**72**	61	69	**28**	**29**
1997	ModWet	**76**	**75**	53	50	**47**	**37**	12	15	**0**	**2**
1984	Wet	**94**	**95**	78	77	**67**	**67**	57	56	**31**	**30**
Avg.		**35.4**	**36.3**	21.6	24.2	**16.5**	**17.6**	8.8	10.9	**3.1**	**3.5**

Attachment 9. Flow changes (on peak day of Gunnison River in May) in Colorado River downstream from the Gunnison River for period of study with proposed plan

Year	May change (cfs) on Gunnison River peak day	Year	May change (cfs) on Gunnison River peak day
1975	+3369	1991	+181
1976	+3256	1992	+2520
1977	-11	1993	+548
1978	+686	1994	+2836
1979	+1097	1995	+2722
1980	+2442	1996	+4552
1981	-2	1997	+2534
1982	+1883	1998	-719
1983	-748	1999	+3644
1984	-21	2000	+3023
1985	+1179	2001	+3952
1986	+2874	2002	+17
1987	+482	2003	+1721
1988	+2378	2004	+1794
1989	+2778	2005	-2207
1990	-3		

Predicted and potential changes in flow as result of proposed action, Colorado River, Colorado-Utah stateline.

Year	Historic peak (cfs)	Potential change in peak (cfs)	Historic avg. monthly flow in May	Predicted change in avg. monthly flow in May	Historic avg. monthly flow in June	Predicted change in avg. monthly flow in June
1975	26,300	+3369	13,150	+301	18,710	+861
1976	14,400	+3256	8,843	+1754	8,881	-191
1977	5,080	-11	2,283	+33	2,688	+118
1978	27,800	+686	11,540	+639	19,690	+1376
1979	36,000	+1097	18,650	-237	22,760	+2143
1980	32,100	+2442	20,300	+357	22,290	+259
1981	12,100	-2	4,600	-3	6,516	+30
1982	19,300	+1883	12,340	+500	16,370	+409
1983	62,100	-748	17,540	-34	41,400	+383
1984	69,800	-21	37,960	-3	43,120	-23
1985	39,300	+1179	28,570	+494	25,280	-135
1986	33,800	+2874	22,370	+246	24,070	+1585
1987	22,500	+482	15,520	+276	11,080	-167
1988	15,400	+2378	8,551	+461	9,108	-52
1989	9,970	+2778	6,651	+703	6,234	-59
1990	12,600	-3	4,078	-3	7,131	-496
1991	19,800	+181	10,610	+293	14,320	-27
1992	16,500	+2520	10,170	+418	7,415	+15
1993	44,300	+548	27,350	-573	25,390	+1293
1994	13,600	+2836	9,912	+969	7,857	-601
1995	49,300	+2722	15,040	+493	33,590	+28
1996	29,100	+4552	18,460	+1275	17,620	+166
1997	37,500	+2534	22,500	+566	29,980	+456
1998	26,100	-719	18,470	-178	12,450	-71
1999	17,900	+3644	9,775	+1178	15,190	-118
2000	17,900	+3023	10,940	+1108	8,640	+359
2001	13,200	+3952	9,017	+1353	6,310	-473
2002	5,520	+17	2,640	-1	2.431	-42
2003	26,100	+1721	9,043	+459	10,100	+16
2004	9,450	+1794	6,615	+459	5,309	-230
2005	31,000	-2207	16,110	-909	15,750	-42

Attachment 10—Redlands, Gunnison River below Redlands Diversion, comparison of days with flows less than 300 cfs and less than 100 cfs in the April through September period

Year	Baseline <300	Plan <300	Baseline <100	Plan <100
1975	0	0	0	0
1976	16	42	0	2
1977	176	179	18	27
1978	0	47	0	0
1979	0	10	0	0
1980	7	9	2	3
1981	8	106	20	24
1982	0	8	0	0
1983	0	0	0	0
1984	0	0	0	0
1985	0	0	0	0
1986	0	0	0	0
1987	0	0	0	0
1988	34	47	5	4
1989	16	46	0	1
1990	64	96	17	12
1991	0	1	0	0
1992	0	0	0	0
1993	0	0	0	0
1994	0	21	0	0
1995	0	0	0	0
1996	0	3	0	0
1997	0	0	0	0
1998	0	0	0	0
1999	11	15	4	5
2000	13	31	0	4
2001	1	17	0	0
2002	140	164	16	28
2003	100	89	8	16
2004	32	75	9	9
2005	0	1	0	0
Avg days	22.3	32.2	3.2	4.4

Attachment 11--Additional guidelines for Aspinall Unit operations included in proposed action

- Aspinall Unit in place, regulating the river and operating for authorized Unit purposes under a wide range of annual inflow conditions.

- At the beginning of the year, water would be released using the most recent January through March inflow forecast and downstream water demands with the goal of achieving a March 31st Blue Mesa Reservoir content target (determined from the January, February, and March 1st forecasted April-July Blue Mesa inflow) and with a goal of higher releases during January for power purposes. The March 31st target is intended to optimize Aspinall Unit storage, flood control, and hydropower production. (Note: The first April through July forecast is received on January 1, after which they are received twice a month through July.) Filling Blue Mesa Reservoir by the end of runoff season is a general goal. Maximum capacity is reached at 7519.4 feet; however, operations are designed to fill to a lesser level to provide a safety factor for controlling the reservoir in case of sudden high inflow due to thunderstorms or high rate of snowmelt.

- Operations will meet at least 300 cfs in the Black Canyon and Gunnison Gorge except in certain cases of significant drought (e.g. as determined by reservoir elevation projections) or emergencies when flows may be reduced to 200 cfs as measured at the USGS Gage below the Gunnison Tunnel. Such a decision will be made only after coordinating with the State of Colorado and other interested/affected parties.

- The Corps of Engineer's flood control manual requires that efforts are made to keep flows below 15,000 cfs. Existing spring flood control operations would be continued using discretion and coordinating with the city and county of Delta in an effort to maintain flows below levels which may cause damage.

- Significant Gunnison Gorge flow decreases that could damage redds from October 15th through May for brown trout recruitment would be avoided when practical. Flow decreases would be avoided after April 15th for rainbow trout spawning when practical. Flow decreases can lead to dewatering or ice damage to eggs.

- Blue Mesa winter icing elevation target, 7490 feet or lower at end of December, will be operated for to reduce chances of ice jams causing upstream flooding in the Gunnison area, for example in the Dos Rios subdivision area.

- The potential exists for modifications to operations under the alternatives as a result of extreme hydrologic conditions, emergencies, or unforeseen conditions. Operational changes in severe or extended droughts could include temporary modifications to any given operation plan for the reservoir and potential short-term modifications to the target flows in the Flow Recommendations. In periods of extreme, multi-year droughts, releases from the Aspinall Unit may have to be reduced to match the inflow to the reservoir during part of the year.

  Operations may be modified due to special maintenance or replacement needs at the Aspinall Unit which may limit outlet capacities or require special downstream flows for repairs and inspections. Special flows may also be needed at some time in the future for repairs or replacement of the Gunnison Tunnel Diversion Dam.

  Emergencies may be associated with dam safety, safety of individuals and groups associated with recreation or other activities on the river, or power system conditions. Emergencies associated with dam safety could require unforeseen releases or operations to protect dam structures. Emergencies related to the safety of individuals may be associated with river rescue or recovery operations. Power emergencies could include insufficient short-term generation capacity, transmission maintenance, and other factors. Emergency power operations are typically of short durations as a result of emergencies occurring at the dam or within the transmission network.

  In the case of emergencies, Reclamation will take appropriate actions immediately and then contact the Service in as timely manner as practical for advice on measures to minimize the effects; and formal consultation, if needed, will be conducted after the fact.

- Peaking power operations conducted at Morrow Point and Blue Mesa will continue with flows downstream from Crystal regulated through constant releases to offset impacts of peaking operations upstream. Blue Mesa power releases will range from 0 to 3,400 cfs and Morrow Point power releases from 0 to 5,000 cfs. During Crystal spills, Morrow Point peaking releases may be reduced to avoid large daily fluctuations downstream from Crystal.

- Alternatives will continue to meet power system requirements of the North American Electrical Reliability Council and the Western Electricity Coordinating Council such as generation control, voltage regulation, black start capability, and reserves. For example, Unit operations--such as Morrow Point peaking—are used in emergency situations to prevent major power problems in the West. Existing power contracts from the Unit would be included (note that CRSP power contracts are not “unit specific” but apply to integrated project facilities). Reclamation will continue to assist Western Area Power Administration (Western) in meeting contract needs while following relevant laws and regulations and the Reclamation/Western MOU.

- The Black Canyon of the Gunnison National Park reserved water right exists but is not quantified. Expected to be quantified but details not determined.

- Morrow Point and Crystal Reservoirs' daily fluctuations will be limited by landslide criteria.

- The Unit will be operated subject to water laws and water rights as decreed under Colorado water law and the Law of the River

- Alternatives honor existing contracts and agreements, including water sales from the Aspinall Unit.

- Existing depletions in the Gunnison River basin from private and public water rights under Colorado law (including evaporation, diversions, transpiration, etc) will continue. Reasonably foreseeable future depletions, based on input from water user representatives, will be included:
    - Assume 3,500 acre-feet (af) of additional depletion in the North Fork area
    - Assume full depletion of Dallas Creek Project water in the Uncompahgre Basin (17,200 af)
    - Assume 8,600 af presently being used under the Upper Gunnison Subordination Agreement
    - Assume additional 22,000 af of future depletion under the Upper Gunnison Subordination Agreement—total depletion under agreement would be 30,800 af in foreseeable future. Ultimate use of full 60,000 af assumed.
    - Assume full depletions of the Dolores Project occurring.

- The proposed action also recognizes that one of the purposes of the Aspinall Unit is "…storing water for beneficial consumptive use, making it possible for the States of the Upper Basin to utilize, consistently with the provisions of the Colorado River Compact, the apportionments made to and among them in the Colorado River Compact and the Upper Colorado River Compact, respectively…". This use is compatible with the Recovery Program which has a goal of fish recovery and water development.

  Remaining project yield" (not precisely known, but up to approximately 300,000 af, minus subordination water use and existing water contracts) will continue to be stored or go downstream and be modeled as such. It is recognized that this remaining water may be developed in the future pursuant to the Colorado River and Upper Colorado River Basin Compacts, and subject to and consistent with the Unit's authorized purposes and other applicable laws. The State of Colorado has consumptive use depletions remaining for use under the Colorado River Compact of 1922 and the Upper Colorado River Basin Compact and a portion of this would legally be available for development using sources in the Gunnison Basin. The unused portion of the Unit yield would not be reserved permanently for flow recommendations. In the EIS, the potential use of the remaining yield is not included in alternatives because specific foreseeable proposals are not available, so that the unused portion of the Unit's yield would be available for meeting the flow recommendations under the alternatives. Alternatives recognize that consumptive use up to a total of 300,000 af of yield may occur in the future under Colorado's compact entitlements. When future water sales or uses of portions of the "remaining project yield" from the Unit are proposed, the proposals will be evaluated under NEPA. If Reclamation determines the proposed sale or use may affect a listed species, formal ESA consultation will commence. If the Upper Colorado River Basin Recovery Implementation Program (UCRIP) has made sufficient progress implementing the Recovery Action Plan, then the UCRIP may serve as reasonable and prudent measures or reasonable and prudent alternatives, as appropriate. The Section 7 Consultation, Sufficient Progress, and Historic Projects Agreement for the UCRIP as revised in 2000 provides information on ESA compliance for future projects, such as use of Aspinall Unit yield.

- Alternatives will include Taylor Park 1975 and 1990 agreements and Taylor Park refill right in place. Aspinall Unit will be operated to protect Uncompahgre Project water stored in Blue Mesa under the Taylor Park Exchange Agreement. The Uncompahgre Project's Gunnison Tunnel and Dallas Creek Project's Ridgway Reservoir exchange will continue in place.

- Operation meetings will be held 3 times per year to discuss operation plans for the Unit.

Attachment 12—Hydrology Modeling

Hydrologic simulation models, such as RiverWare, are essentially mass balance models operating within a rule-based framework to simulate hydrologic interactions between water sources and their uses. Maintaining a water balance assures that the sum of inflows less the sum of outflows equals the change of storage within the basin. Water inflows consist of historic stream flows. Outflows consist of water flowing across the downstream basin boundary (Gunnison River at the confluence with the Colorado River at Grand Junction), Gunnison Tunnel diversions, Redlands Power Canal diversions, and consumptive use (crops, domestic use, natural vegetation, evaporation, etc.). Water storage consists of the water within basin reservoirs. In the Gunnison River model only unnatural (man-induced) hydrologic effects are explicitly modeled. The model uses with the historic inflows and ungaged, gains and losses to river reaches. Starting from this basis eliminates the need to model natural hydrologic processes such as rainfall/runoff. Thus, precipitation falling on natural vegetation, consumptive use by natural vegetation, runoff of excess precipitation, evaporation from the free water surfaces of rivers, etc. is assumed to be reflected in the inflows. Therefore reach gains and losses are not modeled. Likewise, it is assumed that precipitation runoff from man-affected areas (agricultural lands, cities, etc.) is not significantly different from natural conditions to warrant explicit modeling treatment. Thus, the inflows for the simulated water balance of the Gunnison River Basin consist of the historic inflows, stream reach gains. The outflows consist of the man-affected (gaged) flow of the Gunnison River at the confluence with the Colorado River, depletions including consumptive irrigation, domestic use and net (in excess of natural) evaporation from manmade reservoirs.. The change in storage is reflected in the difference between beginning and ending reservoir content. The effects of soil water storage for irrigated lands are incorporated into the historical streamflow and stream reach gains and losses and are not explicitly modeled.
The RiverWare model of the Gunnison River Basin operates on a daily time-step, simulating the flow at every gaging station. The model separates reservoir operations into 3 time periods: January-March, April-July, and August-December. Basic daily inputs to the model are: historic Blue Mesa inflows, both actual and unregulated; historic side inflows to Morrow Point and Crystal; Gunnison Tunnel diversion; and various downstream gains computed from actual gage data. Other data provided as input to the model includes forecasted inflow and tunnel demands for each forecast period.

Forecast data, both reservoir inflow and tunnel demand, is for the current forecast period and can be input on any day; generally on the first day of the month and then on the fifteenth if available. Forecast data for the last month of the forecast period generally has to be adjusted (sometimes daily) to reflect the improved accuracy which occurs at the end of the forecast period. The model determines remaining forecasted inflow and demand by subtracting the inflows or demands to date from the most recent forecast data available. Remaining minimum canyon demands, which include trout spawning and incubation flows, are computed at various times in the model since these demands are dependent upon flows that occur during the model run.

Based on forecasted inflows, forecasted demands (Gunnison Tunnel and Black Canyon requirements), and storage or release of storage, a volume of water that should be released before the end of the forecast period is determined. This volume is generally referred to as the operation volume. Operation volume is converted to a daily flow rate (cfs) and added to the required downstream releases to compute the desired total release. Actual releases equal this desired release unless policy or physical constraints are triggered. Required downstream releases include tunnel diversion and canyon requirements. Canyon requirements include a minimum flow of 300 cfs and the flow needed to minimize impacts to the spawning and incubation of brown and rainbow trout.

Constraints which may be applied to the computed release include ramping rates in the Black Canyon, flood control decisions both at Blue Mesa and Delta, and powerplant limitations.

At Blue Mesa, the daily release is set to be “Canyon Requirement + Gunnison Tunnel Demand-Side Inflow to Crystal and Morrow Point + Crystal Operation Release”. Blue Mesa daily release may be reset by other constraints:

-If the desired Blue Mesa release results in Blue Mesa exceeding its maximum content, release is increased.
-Blue Mesa release is reduced if flow at Delta exceeded 14,000 cfs on the previous day.
-Blue Mesa release adjusted if ramping rates (either up or down) in the canyon are exceeded.
-Blue Mesa release is increased if the minimum brown or rainbow trout spawning or incubation flow, or the minimum canyon flow of 300 cfs is not met. (can occur due to tunnel diversions changing.)
-During Jan-Mar release are limited so that all releases at Crystal go through the powerplant.
-Blue Mesa release will be increased, subject to downstream ramping criteria, if with the current rate of fill, Blue Mesa would have less than 2 feet of storage space remaining at the end of 9 days. Release is the minimum of 6,000 cfs or the release which would result in having 2 feet of storage space remaining.
-If high fall releases are anticipated, June and July flows may be increased. This provides for additional power generation and more stable canyon flows.

In general, Crystal Reservoir release is equal to the Blue Mesa release plus side inflows occurring between Blue Mesa and Crystal.

Operation of the Aspinall Unit to provide peak flows at Whitewater also requires forecasting the time of peak runoff for the North Fork of the Gunnison River, in an attempt to allow releases from Crystal Dam to match the North Fork’s peak. The required timing of the peak release from Crystal Reservoir was adjusted to closely approximate the timing of the North Fork peak, occurring during the last two weeks in May, with the assumption that this level of accuracy in predicting the peak could be reproduced in future operations. For the proposed action modeling, releases to attempt to reach the peak target are made for up to 9 days.

The model in its present configuration represents the best science available to assess the impacts of baseline and proposed operations on various the endangered fish of the Gunnison River.